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DEPARTMENT BULLETIN No. 1485



Washington, D. C.



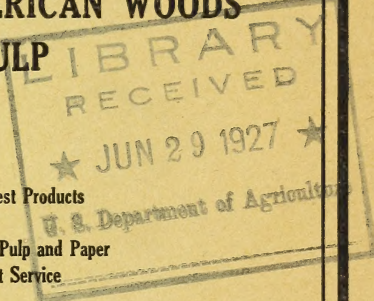
May, 1927

THE SUITABILITY OF AMERICAN WOODS FOR PAPER PULP

By

SIDNEY D. WELLS, Engineer in Forest Products
and

JOHN D. RUE, In Charge of Section of Pulp and Paper
Forests Products Laboratory, Forest Service



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By SIDNEY D. WELLS, *Engineer in Forest Products*, and JOHN D. RUE, *in charge of Section of Pulp and Paper, Forest Products Laboratory, Forest Service*

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INTRODUCTION

SCOPE AND OBJECTS OF THE INVESTIGATION

In 1906 the Forest Service commenced, at its pulp and paper laboratory, then located in South Boston, Mass., a study of the pulping characteristics of American woods for the manufacture of paper pulp. Since that time the work has been continued as one of the major research projects of the service. This bulletin is a report of what may be termed the general or "extensive" phase of the investigation, covering all available species which seemed to offer possibilities.

Most of the 94 species studied have been tested by the soda, sulphate, and sulphite processes. Twenty-two have also been tested by the mechanical process in the commercial sized experimental unit operated at Wausau, Wis., from 1911 to 1914, and

¹ The investigation herein reported was started by the Forest Service in 1906-07 under the supervision of H. S. Bristol, at South Boston, Mass. In 1907 the work was transferred to Washington, D. C., where Edwin Sutermeister was in charge, and since 1910 has been carried on at the Forest Products Laboratory, Madison, Wis. The following have been successively in charge of the section of pulp and paper at the laboratory: H. E. Surface, O. L. E. Weber, Otto Kress, and John D. Rue. Pulping experiments have been supervised by: Mechanical process, J. H. Thickens and G. C. McNaughton; soda and sulphate processes, R. E. Cooper and Sidney D. Wells; sulphite process, R. E. Cooper, C. S. Gwynne, S. E. Lunak, V. P. Edwards, and R. N. Miller. Throughout the investigation the beater and paper-machine runs have been superintended by J. J. Laing.

reported upon in Department of Agriculture Bulletin No. 343, "Ground-Wood Pulp," by J. H. Thickers and G. C. McNaughton. A small compilation of the chemical pulping experiments up to 1912, by H. E. Surface, was published as an unnumbered Forest Service bulletin entitled "Paper pulps from Various Woods." Since 1912 articles on the subject have appeared from time to time in trade and technical journals, but this bulletin is the first attempt to present a report of the survey as a whole.

The work had two objects: (1) To determine the suitability for paper manufacture of species growing on the national forests, so that the Forest Service might be able to guide timber sales efforts intelligently; and (2) to ascertain the relative merits of species not in common use but available to established pulp mills, so that suitable species might be found to supplement the waning supplies of spruce. The results of the investigation of western species have already been used in consummating national forest timber sales have influenced the establishment not only of pulp mills dependent on national forest timber but also of mills dependent on private holdings. The severe shortage of materials experienced by the paper industry in 1919 emphasized the importance of supplementing the supplies of spruce, and it may be profitable to survey briefly conditions as they are now in order to bring out more clearly the possible application of this part of the experimental work.

THE PULP WOOD SITUATION

According to the latest available statistics, one group of conifers, the spruces, supply 55 per cent, and three groups, the spruces, firs, and hemlocks, supply 77 per cent of the wood consumed by the pulp industry of the United States. Table 1 shows the proportion of the material that principal pulp woods supply for each pulping process.

TABLE 1.—*Pulp wood consumption, by species and processes of manufacture, for the United States, 1922*¹

Species pulped	Mechanical process		Sulphite process		Soda process		Sulphate process		Totals by species	
	Cords	Per cent	Cords	Per cent	Cords	Per cent	Cords	Per cent	Cords	Per cent
Spruces.....	1,303,169	87.3	1,650,660	59.7	1,121	.1	77,940	15.5	3,032,890	54.7
Firs.....	89,537	6.0	224,415	8.1			39,378	7.8	353,330	6.4
Hemlocks.....	65,776	4.4	795,980	28.8	3,671	.5	27,768	5.5	893,195	16.1
Poplars.....	8,115	.5	2,135	.1	311,488	39.6	16,193	3.2	337,931	3.1
Yellow poplar.....					102,200	13.0			102,200	1.8
Gums.....					52,058	6.6			52,058	.9
Pines.....	25,240	1.7	9,865	.3	117,094	14.9	270,525	53.9	422,724	7.6
Larches.....	2,100	.1	10,599	.4			55,595	11.1	69,294	1.2
All other species ²	90	.0	71,625	2.6	199,336	25.3	15,169	3.0	286,220	5.2
Total by processes.....	1,494,027	26.9	2,765,279	49.9	786,968	14.2	502,568	9.0	5,548,842	100.0

¹ Based on Table 4, "Pulp wood consumption and wood-pulp production, 1922," Bureau of the Census.

² Includes slabs and other mill waste. Species are basswood, beech, birch, maple, chestnut, cottonwood, Douglas fir, white pine, and willow.

Over 80 per cent of all pulp wood in the United States is consumed in mills situated in the New England, Lake, and Middle Atlantic States. The stand of spruce, fir, and hemlock in this territory is estimated at 3 per cent of the total timber stand of the United States and at about 27 per cent of the total stand of the species mentioned.

As a result of these conditions, pulp wood is now being transported by land and water to many mills over distances of from 500 to 1,000 miles. Imports from the Dominion of Canada are very large. In 1922 Maine depended on Canada for 13 per cent of her spruce, New Hampshire for 35, New York for 64, Pennsylvania for 99, and Michigan for 33 per cent. In addition, 53 per cent of the poplar used by United States mills was imported from Canada. On account of the limited supply and the increased influence of the transportation factor, the average cost of spruce pulp wood f. o. b. mill in the Northeastern States in 1922 was between \$15 and \$28 a cord, depending on whether it was rough, peeled, or rossed.

With steadily rising pulp wood costs the less efficient mills, without their own timber supply, will eventually be forced out of business. It is only by improvement in operation, in processes, in the handling of timber lands, and by the use of other species, that even the better-equipped and managed of the present mills can continue to operate. The use of hemlock by the Wisconsin mills is an example of what can be done with wood once considered unsuitable for pulp.

The necessity for the older mills to turn to other species and to grow their own pulp wood is indicated by United States Department of Agriculture Bulletin 1241, "How the United States Can Meet Its Present and Future Pulp-wood Requirements." It is there stated that because pulp wood use is confined so largely to a small group of species, over one-half of the 9,148,000 cords required to manufacture the United States paper requirements in 1922 were imported as pulp wood, pulp, or paper. Many States are forced to rely upon wood from without their boundaries. In New England and the Lake States, where much of the industry is concentrated, imports of pulp wood and wood pulp are being relied upon to a greater and greater extent to maintain production levels. Throughout the pulp and paper manufacturing regions there are insufficient forest resources to maintain production for an extended period without an intensive program of timber growing, the elimination of waste, a general tightening up in the manufacturing processes, and the extensive use of other than commonly used species for pulp wood.

A study of the distribution of the stand of timber in the United States by species will indicate the supply of pulp wood available for existing mills and what could be added by the use of additional species. Table 2 shows such distribution as accurately as it can be ascertained with the information at present available.

TABLE 2.—*Total stands of timber of principal kinds suitable for pulp, in millions of cords, by regions*

Species of timber	New England	Middle Atlantic	Lake	Central	South Atlantic	Lower Mississippi	Rocky Mountain	Pacific coast	Total United States	South east Alaska
Sulphite, mechanical, and sulphate pulp:										
Spruce and fir.....	185.5	14.0	17.1	3.4	3.4	-----	85.5	205.1	414.0	45.3
Hemlock.....	6.4	23.9	51.3	19.7	6.4	-----	2.5	200.9	311.1	121.4
Jack pine.....	-----	-----	38.4	-----	-----	-----	-----	-----	38.4	-----
Total.....	91.9	37.9	106.8	23.1	9.8	-----	88.0	406.0	763.5	166.7
Soda pulp:										
Aspen and cottonwood.....	6.4	2.2	27.3	10.7	5.1	21.4	12.8	-----	85.9	.2
Birch, beech, maple.....	29.0	80.3	136.8	102.6	16.2	16.3	-----	-----	381.2	.1
Yellow poplar.....	-----	.7	-----	29.9	15.4	1.0	-----	-----	47.0	-----
Basswood.....	2.6	2.2	17.1	10.7	1.7	-----	-----	-----	34.3	-----
Red gum.....	-----	.9	-----	18.8	51.3	97.4	-----	-----	168.4	-----
Black and tupelo gums.....	-----	1.1	-----	21.3	54.7	54.7	-----	-----	131.8	-----
Total.....	38.0	87.4	181.2	194.0	144.4	190.8	12.8	-----	848.6	.3
Sulphate pulp:										
Southern yellow pine.....	1.1	15.1	-----	21.4	453.0	487.2	-----	-----	977.8	-----
Tamarack and larch.....	.9	-----	21.4	-----	-----	-----	34.2	12.8	69.3	-----
White and sugar pines.....	35.0	22.2	21.4	2.5	4.3	-----	42.7	81.2	209.3	-----
Western yellow pine.....	-----	-----	-----	-----	-----	-----	136.8	384.6	521.4	-----
Lodgepole pine.....	-----	-----	-----	-----	-----	-----	128.2	12.8	141.0	-----
Total.....	37.0	37.3	42.8	23.9	457.3	487.2	341.9	491.4	918.8	-----
Regional total.....	166.9	162.6	330.8	241.0	611.5	678.0	442.7	897.4	530.9	167.0
Regional total per cent.....	7.9	8.4	8.9	18.3	24.6	15.5	4.6	11.8	100.0	-----

Taken from Dept. Bull. No. 1241 "How the United States Can Meet Its Present and Future Pulpwood Requirements," by Earle H. Clapp and Chas. W. Boyce.

¹ Contains no allowance for deduction in stand by spruce bud worm, which amounts to 40 per cent or about 27½ million cords in Maine.

In order to make clearer the advantages to be gained by extending the pulp-wood supply to other species, Tables 3 and 4 are presented. These show the amounts of pulp wood consumed in each process in the United States in 1922 and the production of paper by types, together with observations as to the species pulped and the pulps or other raw materials used in the various types of paper.

TABLE 3.—*Pulp wood consumed in the United States, 1922, by processes*

Pulping process	Cords consumed 1922 ¹	Species required
Mechanical.....	1,494,027	Easily ground, white, long-fibered species such as spruces and firs.
Sulphite.....	2,765,279	Nonresinous long-fibered species such as spruces, firs, and hemlocks. Process may be applied to many of the pines and hardwoods.
Soda.....	786,968	Easily pulped, easily bleached hardwoods, such as poplars, birches, maples, beech, and gums. Process may be applied to the conifers.
Sulphate.....	502,568	Any species of conifer. Process may be applied with advantage to hardwoods also.

¹ From Table 1.

TABLE 4.—*Paper production of the United States for 1922*

Kind of product	Tons produced	Pulps or other raw materials used
Newsprint paper.....	¹ 1, 447, 688	Ground wood 80 per cent, sulphite 20 per cent. Old newspapers can be used.
Paper boards.....	2, 153, 835	Old papers, ground wood, sulphate, sulphite, and straw.
Book paper.....	981, 919	Bleached and unbleached sulphite, bleached soda, waste papers free from ground wood, cotton linters, rags.
Wrapping paper.....	836, 271	Sulphite, sulphate, ground wood, old papers, rope, textile waste, straw.
Bag paper.....	212, 122	Sulphate and sulphite.
Fine papers.....	361, 050	Rags, cotton linters, bleached sulphite, bleached sulphate, bleached soda.
Tissue paper.....	197, 524	Rags, sulphite, sulphate, rope, textile waste, flax straw.
Hanging paper.....	91, 894	Old papers, ground wood, sulphite, sulphate, soda.
Felts.....	420, 119	Rags, textile wastes, spent tan bark.
Other grades.....	311, 433	

Compiled from reports of paper production made by the Federal Trade Commission.

¹ 2,530,000 tons of newsprint was manufactured in the United States and Canada in 1922, over 80 per cent of which was consumed in the United States.

On examination of the tables it can be seen how, by the more extended employment of bleached sulphate in book and of semi-bleached or unbleached sulphate in wrapping and bag paper—in many cases with improved results—the use of the more plentiful and less commonly used species may be greatly increased.

Experimental work at the Forest Products Laboratory has demonstrated that the sulphate process applied to the southern pines, in combination with the gums and similar hardwoods of the South, will yield pulps which may be bleached by proper methods and used in the manufacture of book, magazine, and similar high-grade printing papers at reasonable manufacturing cost. The value of this experimental work is emphasized by the fact that the South is advantageously situated in respect to nearness to the publishing centers and availability of fuel, chemicals, and other raw materials. Not only has it enormous quantities of suitable woods available, but owing to climatic conditions the amount of wood which can be grown in the South is from 35 to 40 per cent of the potential productivity of the entire area of forest land in the United States. The growing capacity of unit areas is also very high.

On the other hand, for pulps which require spruce, hemlock, and fir, woods of established value in making paper, there are stands in Oregon, Washington, and Alaska sufficient, under proper timber-growing methods, to supply approximately 5,000,000 cords a year. It has been due largely to economic conditions that the extensive development of these pulp resources has so long been retarded. Up to recent years the only outlet for mills on the Pacific coast has been the local consumption of paper and export to foreign countries. With the rapidly increasing cost of wood in the East greater margins will be created to allow for the cost of transporting pulp and paper from the Pacific coast to other parts of the United States; and such shipments will continue to be an increasing factor in the general situation.

STANDARD PULPING METHODS

At the present time there are two main classes of pulp made from wood, mechanical and chemical.

MECHANICAL PROCESS

Mechanical pulp is made by simply grinding the wood to pulp on a stone, enough water being used to control the temperature. The

wood for grinding is first cut into bolts of the desired length and the bark completely removed. The clean bolts are then ground either hot or cold, according to the character of pulp desired. The difference in the results obtained is largely in the "freeness," or the rate at which water will drain from the pulp on the paper machine. Water will drain away much faster from hot-ground pulp than from cold-ground pulp. Hot grinding, the American practice, is done by adding only sufficient water at the grindstone to keep the temperature of the pulp in the neighborhood of 150° F. In cold grinding, which is more commonly employed in Europe, much larger quantities of water are used, with a resulting temperature very little above the temperature of the water. Some ground-wood pulp is manufactured from wood that has been steamed or boiled before grinding, but the quantity is so small that it is not considered in this publication. The reader is referred to Department Bulletin No. 343, "Ground-Wood Pulp," for more specific information and reports of tests on various species in the manufacture of mechanical pulp.

In the mechanical process, since very little, if any, chemical action takes place, the physical properties of the wood are of first consideration. One of the most important qualities is the color of the wood, which is directly reflected in the color of the pulp obtained. Only the lightest colored woods can be considered for use in the manufacture of newsprint, for which almost all mechanical pulp is utilized. Although the mechanical process is very destructive to the fibers of the wood and their average length is seriously reduced in the operation, nevertheless long-fibered woods, such as spruce, are desired, since the longer the fibers present in the wood the greater the average fiber length of the pulp obtained.

The hardness and structure of the wood are reflected in the power consumed in grinding pulp of standard strength and in the amount of disintegration caused by the action of the stone in tearing the fibers from the mass. Hardwoods with a dense medullary structure consume from two to three times as much power as softer, lighter woods, and their fibers are to a great extent torn to pieces. As a rule, therefore, their use is barred. Woods which give soft, spongy pulps are also undesirable, as are woods which yield pulps composed of mixtures of fine slivers and debris. A measure of control, however, can be exerted over pulp properties by the manner of dressing the stone.

The size and shape of the pieces of wood used in grinding are of considerable importance in the mechanical process with the customary equipment. The greater the number of pieces of wood fed to the grinders per ton of pulp the greater the number of splinters, since from each piece there is usually a thin slab which passes from the pocket without further reduction after a certain minimum thickness is reached.

Specific gravity is an important consideration, because the higher the specific gravity the greater the weight of pulp obtained from a cord.

The pitch content is also important, since, under given conditions, more than a certain amount will cause trouble in the subsequent paper-making operations.

Discolorations in the wood caused by fungi, molds, or bacteria are usually reflected in the pulp obtained. The durability of the wood used in the mechanical process, i. e., its resistance to the organisms of

decay, is, therefore, of great importance. Not only the color but also the physical properties of the pulps, as well as their paper-making qualities, are seriously influenced by decay, which often causes considerable loss of material. Decay has more serious effects in this process than in any of the chemical processes.

CHEMICAL PROCESSES

Of the chemical processes the sulphite, soda, and sulphate processes are standard, and all the wood pulp made by chemical means on a commercial scale is the product of one of the three.

SULPHITE PROCESS

The sulphite process is by far the most important from the standpoint of annual tonnage. It consists of the removal of the incrusting matter in the wood by means of a solution of sulphur dioxide in an aqueous solution of calcium or magnesium bisulphite or a mixture of the two. The pulp is usually light colored and in many products may be used without bleaching. The wood is first barked and then chipped to suitable dimensions to permit proper contact and circulation of the cooking liquor during digestion. As the liquor will not dissolve bark, great care must be exercised in the barking operation; for this reason the size and shape of the wood as received at the mill must be taken into consideration. Round wood down to 3 inches in diameter is used in some instances, but the cost of removing the bark and the relatively large proportion of wood lost in the operation have greatly retarded the use of small material. The same reason has discouraged the use of mill waste from lumbering or wood-working operations, and the quantity of such material reported as having been used in the manufacture of paper pulp in 1920 was actually less than that reported in 1914.

Decay often gives considerable trouble in the manufacture of sulphite pulp, since certain fungi prevent the wood from being completely acted on by the liquor. Discolorations in the wood appear in the pulp, the wood affected is incompletely pulped, and trouble from uncooked portions is encountered.

On account of the acid character of the process, resinous matter, tannins, and other extractive substances are not dissolved, and their presence, by resisting the penetration of the cooking liquor, often prevents complete pulping. In the mill they cause trouble on account of shives or excessive screenings. The pitch particles themselves, either alone or combined or agglomerated with the cooking base, create difficulties on the paper machine in numerous ways familiar to the paper maker.

The spruces, firs, and hemlocks are all capable of reduction by the sulphite process without undue trouble from pitch. Most of the pines, cedars, larches, cypresses, and sequoias, and Douglas fir are too resinous or contain other extractive matter which retards the penetration of the cooking liquor. A few of the pines are used to a limited extent, and it seems probable that with more definite information in regard to the fundamental scientific principles governing the sulphite process the rapidly growing and more easily pulped species such as jack pine, loblolly pine, and Virginia pine will come into more general use, especially when the wide range of some of

them is considered. Although some of these species may give as high as 6 per cent screenings on account of knots or small local portions more resinous than the rest of the wood, the uncooked portions can usually be successfully removed with standard equipment, leaving relatively clean pulps of satisfactory color. The pines of the white pine series that were tested (northern white pine, sugar pine, limber pine, and piñon) can not be satisfactorily pulped, even though on inspection they show less resin than the other pines mentioned above. Although the amounts of screenings are small, the pulps contain particles of partially cooked wood which pass through the screen plate slots with the fiber and cause the pulps to be specky and of poor color. Not only do the extractive substances affect penetrability, but often the structure of the wood itself has considerable influence, and many species show differences in cooking which can be attributed only to this cause.

Although the fibers are separated by the sulphite process without reduction in ultimate length, fiber length is of such importance that, as a rule, only long-fibered woods are pulped in this way. The color is usually of minor significance, except in the case of deeply colored woods, whose coloring substances are often not dissolved in the cooking operation, so that the color of the pulps is affected.

Specific gravity of the wood has the same importance in affecting the yield per cord as in the case of ground-wood pulp, and it also directly affects the quantity of wood per digester charge and thereby the output of the mill.

The bleachability of the pulp and the ease or difficulty of hydration are important considerations. They both depend to a considerable extent on the cooking conditions.

Although the soda process is generally used on hardwoods on account of the greater opacity of the pulp, the sulphite process produces from many species (such as the birches, maples, and gums) greater yields of pulp that can be bleached with much lower consumption of bleach.

SODA PROCESS

The soda process is almost entirely devoted to the pulping of hardwoods. When the Forest Service pulping experiments were started the species in commercial use were the true poplars, yellow poplar, the soft maples, basswood, and possibly a few other of the most easily pulped species. At present, by the use of improved methods, birches, hard maples, gums, beech, chestnut, sycamore, and numerous others are also being pulped. The pulp is usually bleached. It holds loading materials and takes coatings well. It also possesses soft, bulky, and absorbent qualities which, when it is properly mixed with bleached or unbleached sulphite, give an opaque, well felted, and well formed sheet of paper highly esteemed by the printer. Soda pulp is consequently used largely in the manufacture of book, magazine, lithograph, and other papers for printing purposes, and considerable quantities are employed in the manufacture of blotting paper.

The soda process can be applied without difficulty to coniferous woods and to a limited extent is so applied. Usually, however, the greater strength and toughness of pulp produced by the sulphate process from the same wood has limited the use of the soda process for producing strong pulps. Soda pulp from conifers is hard to bleach, and the process is, therefore, little used for bleached pulp

from such species. It is not, however, handicapped by the disagreeable odor characteristic of sulphate mills, which is probably the reason it has not been supplanted entirely by the more recent process.

The soda process consists of the disintegration and solution of the incrusting matter in the wood by means of an aqueous solution of sodium hydroxide, the wood being prepared in a manner similar to that used in the sulphite process. It is not so important, however, to remove entirely the bark, knots, or decayed portions, because under proper conditions the soda liquor disintegrates them. Nevertheless, the wood is usually peeled so as to avoid the consumption of alkali in the solution of the bark or of decayed portions which yield no pulp.

Pitch is not objectionable in the soda process, as it is readily dissolved in the cooking liquor. Tannins, however, consume caustic soda and make necessary the use of larger quantities. Also tannins not removed (by means of water extraction) before the cooking operation usually darken the pulp and render it much more difficult to bleach.

Although fiber length is important, it is not so much so as in the sulphite process, because soda pulp is used almost entirely in the manufacture of printing papers where printing qualities outweigh strength. The color of the wood is also a minor factor, since the coloring matter is in many cases dissolved by the liquor and removed from the pulp. With some woods, however, the coloring matter persists throughout the cooking action, and is apparent in the pulp.

The specific gravity of the wood has the same importance as in the sulphite and mechanical processes.

SULPHATE PROCESS

The sulphate process, only recently introduced into America, was first used in continuous commercial operation in Quebec in 1907. Since that time the production of sulphate pulp has increased very rapidly. In 1914 about 52,000 tons were produced in the United States. By 1922 production had risen to over 243,000 tons. The reasons for this increase are the larger yields of pulp and the greater strength of the paper.

It is a modification of the soda process in which the active ingredients of the cooking liquor consist of caustic soda and sodium sulphide, usually in the proportion of 2 to 1. Its use is confined almost entirely to conifers. There is no reason why it should not be applied to hardwoods; with the majority of these species easier bleaching pulps are obtained with equal yields. The unbleached pulp from conifers is commonly used in the manufacture of kraft wrapping paper or, in combination with waste papers, for high-test container board.

Although the practice of bleaching sulphate pulp is not very prevalent, work at the Forest Products Laboratory has demonstrated that by using modified methods of bleaching with the standard solutions, and with quantities of bleaching powder not in excess of common commercial practice, very satisfactory results may be obtained. Although the pulp obtained by ordinary methods of bleaching is yellow and does not approach the brilliant white characteristic of bleached sulphite pulp, pulp comparable in brightness is obtained by the modified methods. The opacity of the bleached pulp is

usually greater than that of bleached sulphite pulp. It thus becomes possible to obtain from sulphate pulp papers having printing properties superior to those of papers from bleached sulphite pulp, unless the latter is combined with bleached soda pulp from hardwoods.

The main drawback of the sulphate process lies in the disagreeable odors which characterize it; on this account the mills are usually located on the fringes of population.

The wood is usually barked, although in some mills this step is omitted and any fragments of bark which pass the screening operation are dissolved in the digester. The consequent high consumption of cooking liquor without any return, however, makes it more economical to bark the wood before chipping. Decayed wood does not affect the quality of the pulp as it does in the sulphite process,

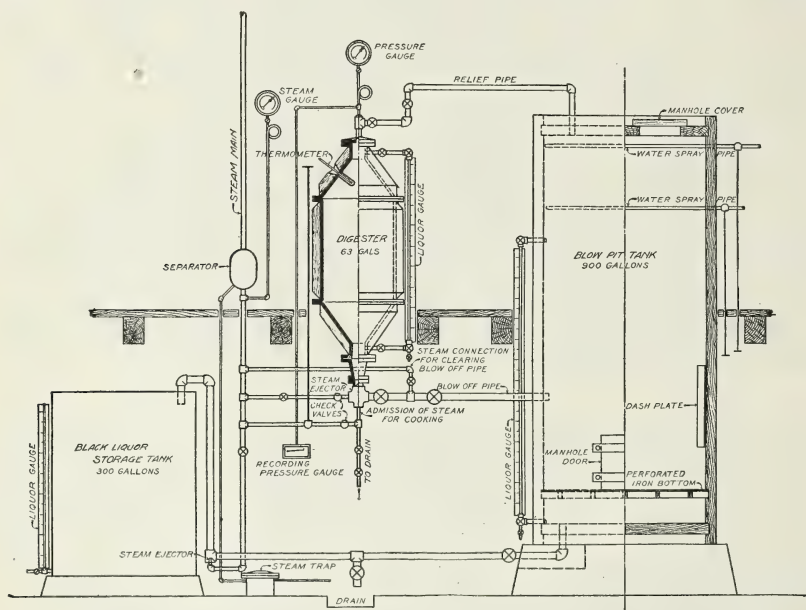


FIG. 1.—Digester used for alkaline cooks prior to 1916, and for sulphite cooks prior to 1911

but it very seriously affects the yields and consumption of alkali to a ton of pulp. The durability of the wood used is therefore an important consideration from the economic standpoint.

Charred wood is objectionable in this process (as well as in the others), since the particles of carbon survive the cooking operation and appear in the pulp. Pitch, fats, or waxes occasion no trouble, these being readily soluble in the sulphate liquors and furnishing to the cooking liquor combustible matter which helps later in the recovery of the soda.

The penetrability of the wood is a considerable factor in the quality and uniformity of the pulp. The length of the fibers is of major importance, as sulphate pulps are ordinarily used for purposes where strength is required. The color of the wood is a secondary consideration except in a few instances where the coloring matter survives the cooking operations. The specific gravity of the wood is directly reflected in the yield of pulp obtained per cord.

EXPERIMENTAL PROCEDURE ²

EQUIPMENT

In the course of the Forest Service experiments several digesters were used for making the cooks. In Figure 1 is shown the lead-lined digester which was used until 1911. From 1911 to 1916 the same equipment, with the lead lining removed, was used for the alkaline cooks only, the equipment shown in Figure 2 being used for the sulphite cooks. Since 1916 the equipment shown in Figures 3 and 4 has been used for the sulphite cooks and that in Figures 5 and 6 for the alkaline cooks. All these digesters held between 60 and 70 gallons, and all gave similar results. All were stationary with the exception of the one shown in Figures 3, and 4, which could be revolved on trunnions to obtain positive circulation. In all the digesters except the earliest, indirect heat as well as direct steam

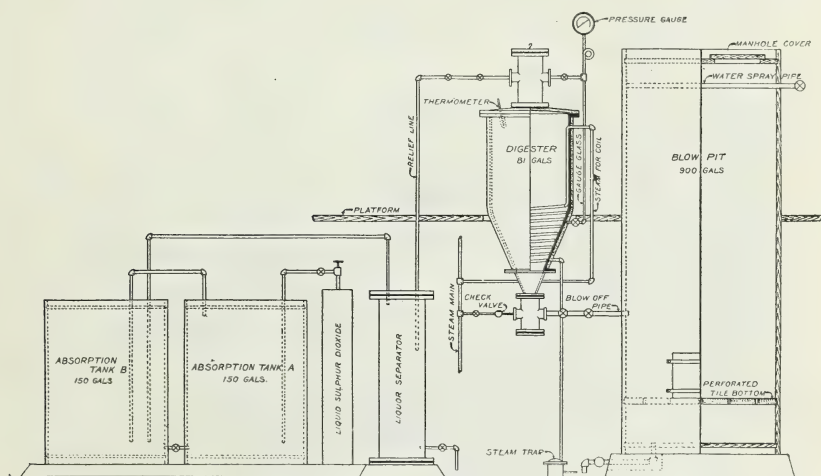


FIG. 2.—Digester used for sulphite cooks from 1911 to 1916, inclusive

was supplied in order to overcome the excessive radiation characteristic of small-sized apparatus. By that means condensation was obtained comparable in amount to that in commercial equipment. The chipper used was of the usual disk type but of laboratory size. Figure 7 shows the semicommercial beater used, and Figure 8 the combination 12-inch cylinder and Fourdrinier paper machine on which the paper samples were made. Operating in conjunction with the paper machine was a Jordan refining engine of laboratory size, so that the results obtained were comparable to mill practice.

CONDUCT OF TESTS

The chips, cut five-eighths along the grain, were carefully screened to remove sawdust, bark, large pieces, and large knots. Before charging, the moisture content of the wood was determined and the quantities of cooking chemicals and the volume of liquor were calculated from the oven-dry weight of the wood. During cooking,

² Tests on chemical pulps only. For experiments on mechanical pulps see THICKENS, J. H., and McNAUGHTON, G. C., GROUND-WOOD PULP. Dept. Agr. Bul. 343, p 151, illus., 1916.

pressure and temperature were carefully regulated and observations recorded at 15-minute intervals. At the end of the cooking period samples of liquor were taken and, in the case of sulphite cooking, analysis was made and color observed. The digester contents were then discharged into the blow pit. There the pulp was washed free of cooking liquor and drained. In the case of impregnation cooks the digester was completely filled with chips and cooking

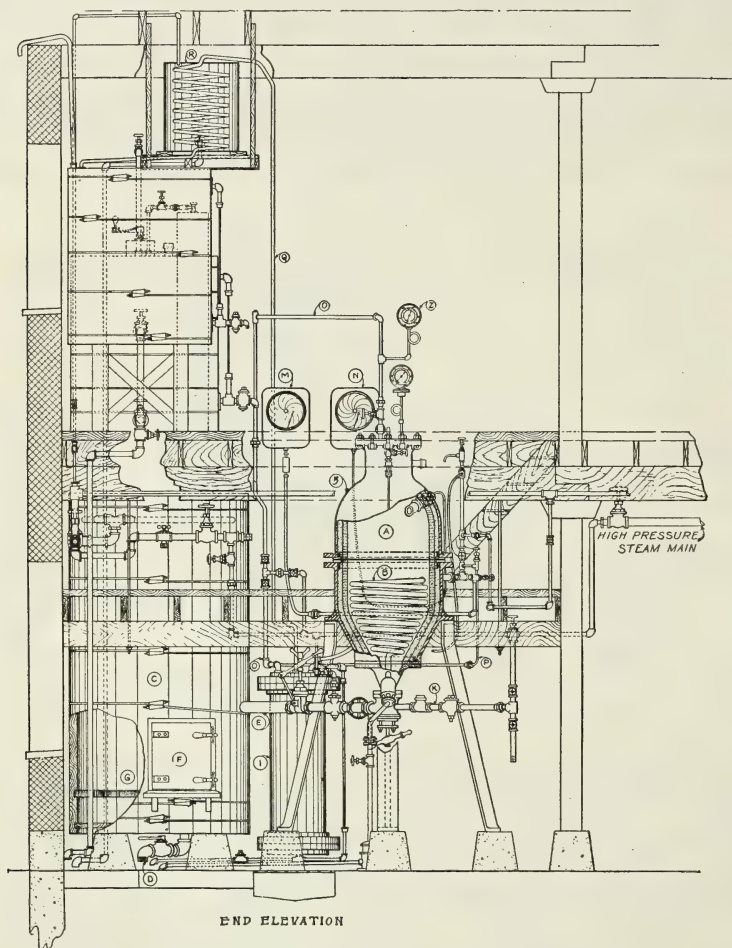


FIG. 3.—Digester used for sulphite cooks since 1916 (end elevation)

liquor and the cover bolted on. The pressure tank, I in Figure 3, was next filled, and, by forcing steam into the top of I and opening the connections therefrom to the digester, hydrostatic pressure was set up around the chips, forcing the liquor into them until at the end of from 15 to 30 minutes at a pressure of from 100 to 110 pounds to the square inch they were well penetrated. The digester was then inverted, the valves in the relief pipe L and pipe O (fig. 4) were opened, and the proper quantity of liquor was blown back

into tank X from which it was originally obtained, steam being admitted to the digester above it to supply the force necessary. By weighing and analyzing the liquor before impregnation and during its return the quantity of chemical remaining in the digester could be determined and controlled. After sufficient liquor had been returned to the tank to leave the desired quantity in the digester, the connections referred to were closed, water was added if necessary

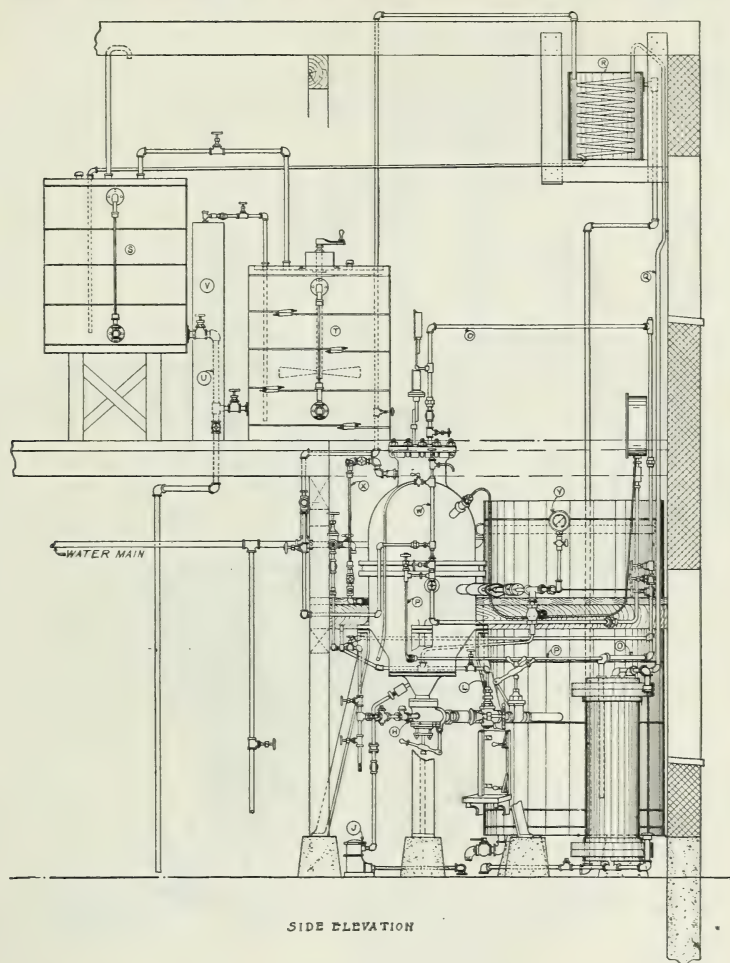


FIG. 4.—Digester used for sulphite cooks since 1916 (side elevation)

to give the desired volume in the digester, and the cook was carried on in the usual manner. The usual procedure applied also to screen- and other treatments.³

After the pulp was completely washed and drained it was hydraulically pressed, opened up in a swing-hammer shredder, and weighed and sampled for moisture. From the moisture determination the

³ KRESS, OTTO, WELLS, SIDNEY D., and EDWARDES, VANCE P. NAMES FIRST THE EQUIPMENT AND OPERATION OF AN EXPERIMENTAL LABORATORY. Paper, April 19, 1920.

bone-dry weight of the pulp was ascertained, and thereby the yield. The pulp was then passed through a diaphragm screen and the screenings were dried and weighed. Samples of the pulp were

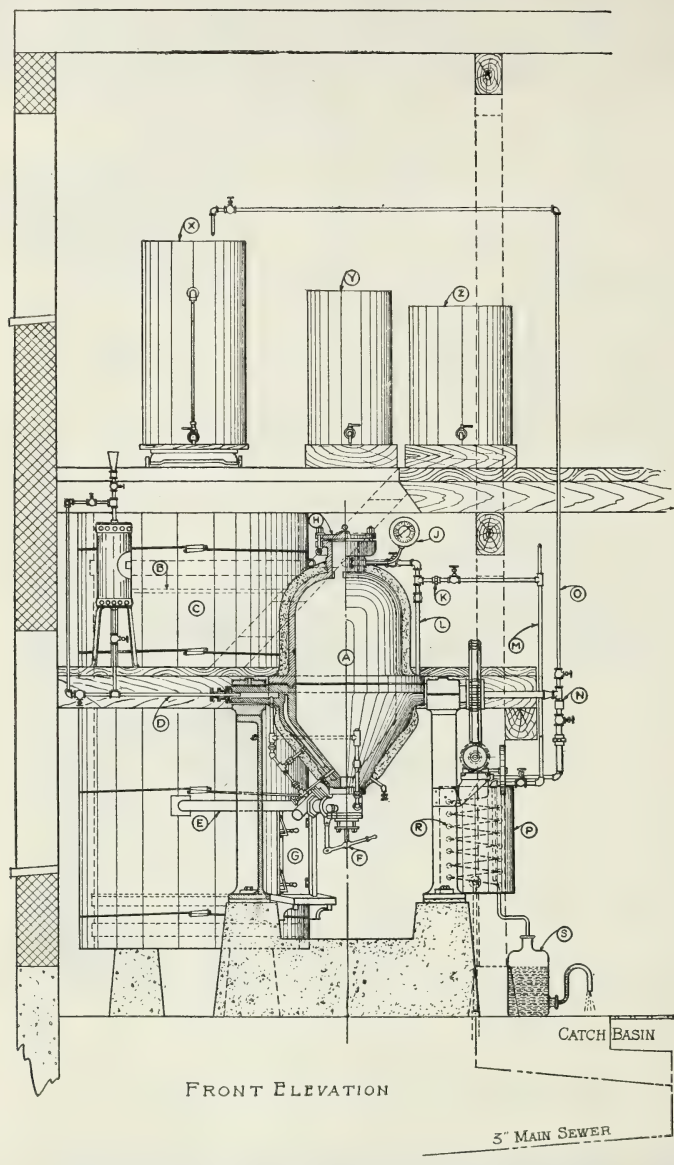


FIG. 5.—Digester used for alkaline cooks since 1916 (front elevation)

saved for bleach tests; the rest was treated in the beater to produce the desired quality of waterleaf paper and was run over the machine.

Standard strength tests were made on the papers obtained.

Bleaching tests were made by treating various samples of equal weight with quantities of bleach ranging from 5 to 40 per cent of

the weight of the pulp, according to requirements estimated from preliminary observations. Forty grams of pulp in 1,600 cubic centimeters of total liquid were used in each test. The mixture

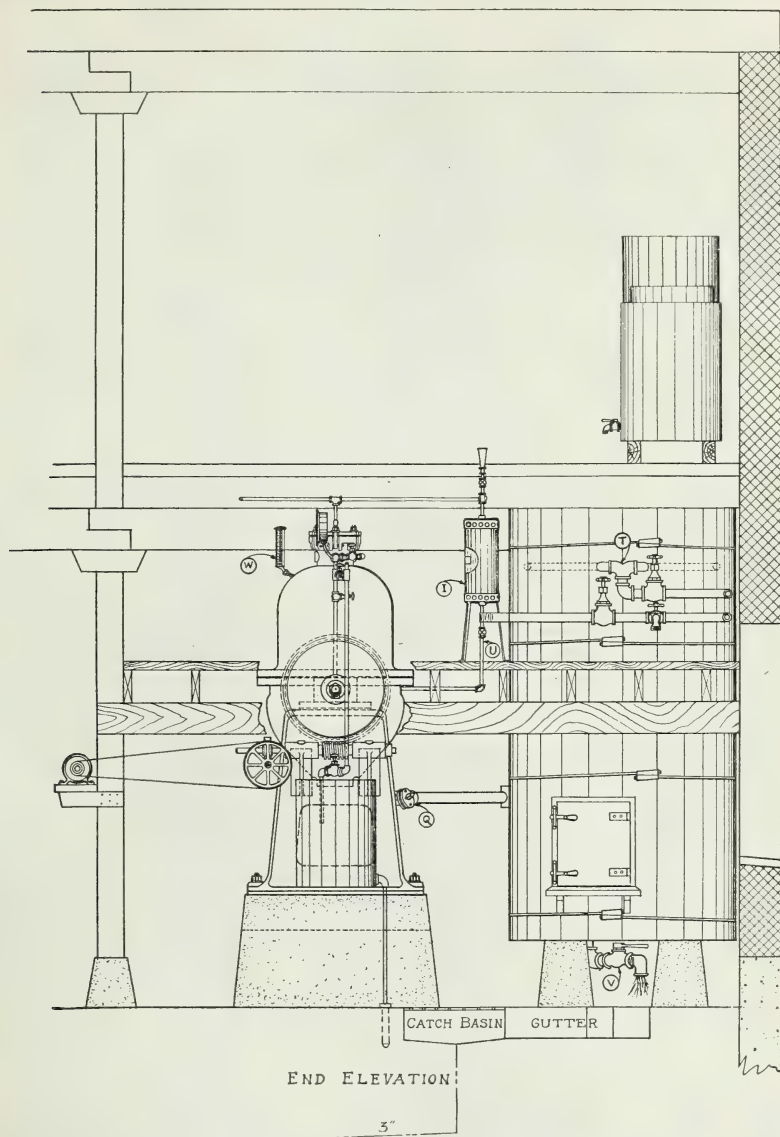


FIG. 6.—Digester used for alkaline cooks since 1916 (end elevation)

was kept in constant agitation at a temperature of between 100° and 110° F. until the bleach was exhausted. Hand sheets were made of the pulp, and the measure of bleaching was taken as the quantity of bleach beyond which no improvement in color was observable.

SPECIES INVESTIGATED

The species tested are listed in Table 5, together with their botanical names and the locality where the material obtained was grown.

TABLE 5.—*Species tested, and locality of growth*

Common name	Botanical name	Where grown
Softwoods:		
Black spruce.....	<i>Picea mariana</i>	Wisconsin.
Blue spruce.....	<i>Picea pungens</i>	Colorado.
Engelmann spruce.....	<i>Picea engelmannii</i>	Idaho.
Norway spruce.....	<i>Picea abies</i>	Iowa.
Red spruce.....	<i>Picea rubra</i>	Tennessee.
Sitka spruce.....	<i>Picea sitchensis</i>	Oregon.
White spruce.....	<i>Picea glauca</i>	Wisconsin.
Limber pine.....	<i>Pinus flexilis</i>	Colorado.
Piñon.....	<i>Pinus edulis</i>	Do.
Sugar pine.....	<i>Pinus lambertiana</i>	California.
Northern white pine.....	<i>Pinus strobus</i>	Wisconsin.
Jack pine.....	<i>Pinus banksiana</i>	Do.
Loblolly pine.....	<i>Pinus taeda</i>	Virginia and South Carolina.
Lodgepole pine.....	<i>Pinus contorta</i>	Montana.
Long-leaf pine.....	<i>Pinus palustris</i>	Louisiana.
Monterey pine.....	<i>Pinus radiata</i>	California.
Norway pine.....	<i>Pinus resinosa</i>	Wisconsin.
Pitch pine.....	<i>Pinus rigida</i>	Tennessee.
Pond pine.....	<i>Pinus rigida serotina</i>	South Carolina.
Sand pine.....	<i>Pinus clausa</i>	Florida.
Scotch pine.....	<i>Pinus sylvestris</i>	Iowa.
Virginia pine.....	<i>Pinus virginiana</i>	Maryland and Tennessee.
Short-leaf pine.....	<i>Pinus echinata</i>	Louisiana.
Slash pine.....	<i>Pinus caribaea</i>	Florida.
Western yellow pine.....	<i>Pinus ponderosa</i>	Oregon.
Pehuén (Monkey-puzzle).....	<i>Araucaria araucana</i>	Argentina.
Alpine fir.....	<i>Abies lasiocarpa</i>	Montana.
Balsam fir.....	<i>Abies balsamea</i>	Wisconsin.
Lowland white fir.....	<i>Abies grandis</i>	Washington.
Noble fir.....	<i>Abies nobilis</i>	Oregon.
Red fir.....	<i>Abies magnifica</i>	California.
Silver fir.....	<i>Abies amabilis</i>	Washington.
White fir.....	<i>Abies concolor</i>	California and Oregon.
Douglas fir.....	<i>Pseudotsuga taxifolia</i>	Oregon.
Carolina hemlock.....	<i>Tsuga caroliniana</i>	Georgia.
Eastern hemlock.....	<i>Tsuga canadensis</i>	Wisconsin.
Western hemlock.....	<i>Tsuga heterophylla</i>	Washington.
Tamarack.....	<i>Larix laricina</i>	Wisconsin.
Western larch.....	<i>Larix occidentalis</i>	Montana.
Incense cedar.....	<i>Libocedrus decurrens</i>	California.
Port Orford cedar.....	<i>Chamaecyparis lawsoniana</i>	Oregon.
Southern white cedar.....	<i>Chamaecyparis thyoides</i>	North Carolina.
Eastern red cedar.....	<i>Juniperus virginiana</i>	Arkansas.
Western red cedar.....	<i>Thuja plicata</i>	Washington.
Southern cypress.....	<i>Taxodium distichum</i>	Missouri.
Redwood.....	<i>Sequoia sempervirens</i>	California.
Hardwoods (diffuse-porous):		
Aspen.....	<i>Populus tremuloides</i>	Wisconsin.
Balsam poplar.....	<i>Populus balsamifera</i>	Montana.
Eastern cottonwood.....	<i>Populus deltoides</i>	Wisconsin.
Norway poplar.....	<i>Populus canadensis eugeni</i>	Minnesota.
Large-tooth aspen.....	<i>Populus grandidentata</i>	Wisconsin.
Yellow poplar.....	<i>Liriodendron tulipifera</i>	West Virginia.
Basswood.....	<i>Tilia glabra</i>	Wisconsin.
Black willow.....	<i>Salix nigra</i>	Missouri.
Sandbar willow.....	<i>Salix longifolia</i>	Ohio.
Red alder.....	<i>Alnus rubra</i>	Washington.
Balsa.....	<i>Ochroma lagopus</i>	Canal Zone.
Box elder.....	<i>Acer negundo</i>	Wisconsin.
Red maple.....	<i>Acer rubrum</i>	South Carolina.
Sugar maple.....	<i>Acer saccharum</i>	Michigan.
Paper birch.....	<i>Betula papyrifera</i>	New Hampshire.
Yellow birch.....	<i>Betula lutea</i>	Wisconsin.
Beech.....	<i>Fagus grandifolia</i>	Pennsylvania.
Black gum.....	<i>Nyssa sylvatica</i>	South Carolina and Tennessee.
Tupelo gum.....	<i>Nyssa aquatica</i>	Louisiana and Florida.
Red gum.....	<i>Liquidambar styraciflua</i>	Tennessee and South Carolina.
Cucumber magnolia.....	<i>Magnolia acuminata</i>	West Virginia.
Sweet bay.....	<i>Magnolia virginiana australis</i>	Florida.
Sycamore.....	<i>Platanus occidentalis</i>	Maryland.
Butternut.....	<i>Juglans cinerea</i>	Virginia.
Ohio buckeye.....	<i>Aesculus glabra</i>	Tennessee.
Mangrove.....	<i>Rhizophora mangle</i>	Florida.

TABLE 5.—*Species tested, and locality of growth*—Continued

Common name	Botanical name	Where grown
Hardwoods (ring-porous):		
Common catalpa.....	<i>Catalpa bignonioides</i>	Kansas.
Chestnut.....	<i>Castanea dentata</i>	Virginia.
Hackberry.....	<i>Celtis occidentalis</i>	Indiana.
Sassafras.....	<i>Sassafras varifolium</i>	Tennessee.
Rock elm.....	<i>Ulmus racemosa</i>	Wisconsin.
Slippery elm.....	<i>Ulmus fulva</i>	Indiana.
American elm.....	<i>Ulmus americana</i>	Wisconsin.
White ash.....	<i>Fraxinus americana</i>	Arkansas.
Red oak.....	<i>Quercus borealis maxima</i>	Tennessee.
White oak.....	<i>Quercus alba</i>	Do.
Mockernut hickory.....	<i>Hicoria alba</i>	Virginia.
Black locust.....	<i>Robinia pseudoacacia</i>	Georgia.
Ailanthus.....	<i>Ailanthus altissima</i>	Pennsylvania.
Miscellaneous:		
Soapweed.....	<i>Yucca elata</i>	Arizona.
Cabbage palmetto.....	<i>Sabal palmetto</i>	Florida.
Cane.....	<i>Arundinaria macrosperma</i>	Louisiana.
Chilean woods:		
Olivillo.....	(?).....	Chile.
Laurel.....	<i>Laurelia aromatica</i>	Do.
Coigue.....	<i>Nothofagus dombeyi</i>	Do.
Lingue.....	<i>Persea lingue</i>	Do.
Roble pellin.....	<i>Nothofagus obliqua</i>	Do.
Quillai.....	<i>Quillaja saponaria</i>	Do.

The material was selected from localities, within the commercial range of the species, where average conditions existed. Representative specimens were taken and efforts were made to maintain the amounts of heartwood and sapwood in the chips at as nearly as possible the same proportions as would occur in the usual run of pulp wood at the mill.

The Chilean woods listed were tested in response to a request from the Department of State in 1913. The species studied were submitted by Alejandro Rosselot, of Santiago, Chile, and represented what he considered the most important Chilean species from the standpoint of paper manufacture. At a later date tests were made on pehuen (*Araucaria aurocana*) submitted by a Chicago lumber concern, the material having been obtained from a stand about 500 miles south of Mendoza, Argentina, on the eastern slope of the Andes. The species is native to both Argentina and Chile. The data here presented on South American species are not at all complete. Much more detailed information as to the extent of the stands of various species, paper consumption, transportation facilities, labor, fuel, water supply, etc., will be necessary before any application of the pulping data is warranted.

PULPING CHARACTERISTICS OF GROUPS OF WOODS

SOFTWOODS

All of the spruces tested are suitable for pulping by any of the processes and are capable of yielding pulp of the best quality. The main considerations with the spruces are the size, straightness, and density of the wood. Although they vary somewhat in fiber length, even the species with the shortest fiber are capable of producing pulp of the best quality.

The hemlocks are used in all chemical processes. Sulphite pulp from hemlock hydrates more readily than that from spruce and will

not make paper of quite as great strength. The unbleached pulp is darker and requires more bleach. Western hemlock is much more easily pulped than eastern hemlock, and the pulp more nearly resembles that from spruce. Western hemlock is used to a certain extent in the manufacture of mechanical pulp, but the power requirements to produce pulp of the same strength as spruce are somewhat greater; or, if pulp is produced with the same power consumption, a weaker pulp requiring more sulphite in the manufacture of standard newsprint is obtained.

The firs can be used in all the processes. They produce pulp very similar to that from spruce in practically every characteristic. With

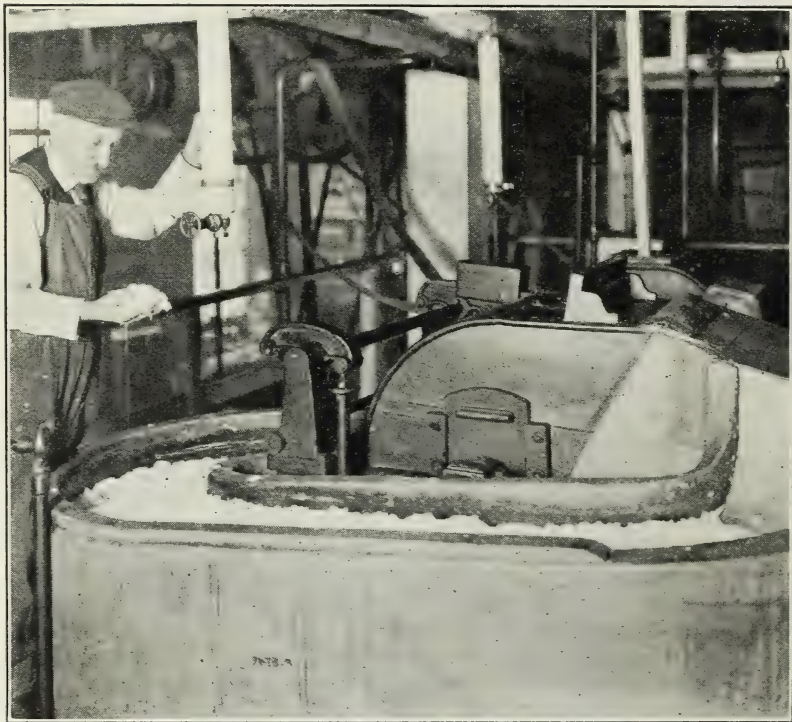


FIG. 7.—Beater of semicommercial type used in the pulping experiments

red fir, however, both the sulphite and mechanical pulps are darker colored, and the sulphite is more difficult to bleach.

As to the pines, general statements can not be made with the same assurance. Lodgepole pine and western yellow pine have been used successfully in extensive experiments in the manufacture of mechanical pulp, the color of which was satisfactory and the strength, power consumption considered, closely comparable to that of spruce. Under the sulphite process, jack pine, loblolly pine, lodgepole pine, Norway pine, pond pine, sand pine, and Virginia pine yielded pulp of very fair quality, capable of bleaching with reasonable quantities of chemical. In the case of loblolly pine, lodgepole pine, Norway pine, sand pine, and Virginia pine the uniformity of the digestion

was very satisfactory. With jack pine and pond pine the screenings ran from 3 to 6 per cent—which, however, is not prohibitive.

Northern white pine, sugar pine, limber pine, and piñon are all capable of manufacture into mechanical pulp of excellent quality. In the sulphite process, however, penetration by the cooking liquors is very slow and the results are unsatisfactory. All the pines reduce readily under the alkaline processes and produce pulp that may be bleached, although the product is less satisfactory than the standard bleached sulphite pulps.

Larches, Douglas fir, southern cypress, and cedars with light-colored wood can be pulped by the sulphite process, although with

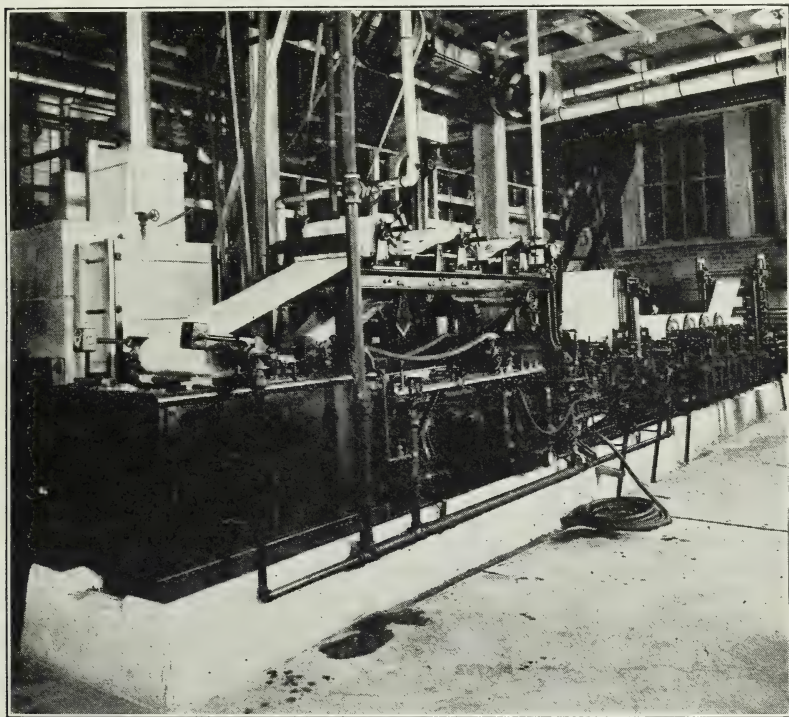


FIG. 8.—Combination cylinder and Fourdrinier paper machine upon which the paper samples were made

more difficulty than hemlock. The quantities of bleach required are high but are within the range of commercial feasibility. None of these woods has been satisfactorily reduced by the alkaline processes to pulp bleachable with a reasonable quantity of bleach. Southern cypress is the most difficult. Redwood and cedars with dark-colored wood are very difficult to pulp or to bleach by the sulphite process. Consideration of the mechanical processes for these woods is not warranted, owing to their dark color. Their light weight and consequently the low yields obtained discourage consideration of them for the alkaline processes, although very satisfactory pulps for unbleached wrapping paper can be obtained.

In the case of species more or less resinous, it frequently happens that by the mechanical or sulphite-processes pulps of satisfactory strength and color can be obtained, but that the presence of "pitch" gives rise to operating difficulties in the paper mill. The laboratory experimental runs in which the pulps were studied were so short that the degree to which "pitch" troubles would be encountered was not ascertained accurately. It is possible that the difficulties would be decreased or eliminated by a judicious use, on the grinders or in the beaters, of some highly colloidal material such as bentonite. At the suggestion of the laboratory staff bentonite has been used commercially in both sulphite and mechanical pulping operations, with satisfactory results. It may become an important factor in extending the use of resinous pulp woods.

HARDWOODS

The fibers of hardwoods are short and hence not suited to the manufacture of strong, tough papers. They do, however, contribute to the formation of a well-closed, smooth-surfaced sheet of the type that is essential for a satisfactory print paper. In news and similar cheap print papers this characteristic is obtained more economically by the addition of ground wood than by the addition of a short-fibered chemical pulp; hence bleached hardwood chemical pulps find their most extensive use in print papers of the higher grades. The alkaline-cooked pulps, by virtue of their softness, bulk, and opacity, are most favored. The sulphite pulps are harder and less opaque but yield better, bleach whiter, and require less bleach. Their lack of opacity may be overcome by the addition of mineral fillers. A more extensive use of hardwood sulphite pulps in the manufacture of book, envelope, and similar paper may be expected, especially in paper mills that are already equipped for the production of sulphite.

The following hardwoods, with diffuse-porous structure, can be reduced readily by the sulphite process and bleached with small quantities of chemical: Poplars, willows, maples, birches, gums, magnolias, sycamore, and butternut. Of these with ring-porous structure, hackberry, elm, ash, and hickory can be readily or fairly readily pulped and bleached. The pulp usually contains small dark-colored specks, which, however, disappear on bleaching. Of diffuse-porous woods difficult to pulp and bleach to a satisfactory product there were tested basswood, red gum, and Ohio buckeye; of ring-porous woods difficult to pulp and bleach, common catalpa, chestnut, sassafras, slippery elm, red and white oak, and black locust. In both cases the difficulty of pulping is probably due to extractive matter or to structure which prevents penetration of the wood by the cooking liquor.

The hardwoods, in general, are unsuited to the manufacture of mechanical pulp, on account of the high power consumption required and the weakness of the pulp. By the adoption of new principles in grinding, however, it may become practicable to use the lighter colored of the hardwoods, such as the poplars, birches, and gums, for the manufacture of mechanical pulp.

All the hardwoods are capable of reduction by the soda or sulphate processes. The poplars and basswood among the diffuse-porous species are very easily pulped and bleached, and yellow poplar, willows, soft maples, beech, red alder, and balsa fairly easily. The

birches, hard maples, gums magnolias, Ohio buckeye, butternut, and mangrove are rather difficult but are within the realm of profitable utilization. Of the ring-porous woods chestnut, after extraction, and the elms are fairly easily pulped and bleached. Unextracted chestnut, however, yields a pulp which is very inferior and very difficult to bleach. Common catalpa, hackberry, and white ash are rather difficult; sassafras, red and white oak, mockernut hickory, and black locust are very difficult.

BARK DISPOSAL

In considering the availability of various species for paper pulp the question of the utilization of the bark removed in the preparation of the wood naturally occurs. The feasibility of such utilization depends to a very large extent on local conditions, and each species and locality should be studied independently. Attempts to make use of this waste have met with considerable success in a number of cases. The most obvious means of utilization is as fuel, and at many mills it is found that the burning of the bark supplements the fuel supply to an appreciable extent. This is especially true if the bark is obtained from knife barkers or, in case the wood is barked wet in drum barkers, if as much water as possible is removed by means of a press before feeding to the furnaces. The barks from some species, such as hemlock, contain sufficient tannin to justify recovery of the latter by means of water extraction before burning. Extracted hemlock tanbark has also been found a suitable material for use with rags for the manufacture of roofing felt, and considerable quantities have been used for that purpose. Redwood bark is so utilized on a commercial scale.

Experiments with bark from the southern pines indicate that satisfactory roofing felt may be made with it by adding enough sulphate pulp from the same wood to give the required strength for passing through the impregnating bath. Spruce bark has been used as a portion of the furnish in the manufacture of board and cheap wrapping papers, such as car liner. Balsam fir and spruce barks have been used in finely shredded form in the manufacture of heat-insulation material.

SUITABILITY OF INDIVIDUAL SPECIES FOR PULPING

Descriptive summaries dealing with the pulping characteristics of various species under one or more of the various processes are given on pages 25 to 65. These summaries include brief statements about names of species, their range, specific gravity, and fiber length.

The information on names and range is based on the revised "Check List of the Forest Trees of the United States," by George B. Sudworth (United States Department of Agriculture (Miscellaneous Circular 92.)

ESTIMATION OF PULPING VALUE

All statements appearing in the summaries as to yields and quality of pulp and consumption of bleach are to be regarded as estimates of results to be expected under commercial operating conditions. In arriving at such estimates the writers have considered, (1) under the chemical pulp, the results of a limited number of laboratory tests on each species—usually not more than two or three for each pulping process—the data for which are recorded in Tables 6 to 12, and, under

the mechanical pulps, the results published in Department Bulletin No. 343, "Ground-Wood Pulp"; (2) the relation of yield and quality of pulp to particular conditions of pulping and to the characteristics of individual woods; and, (3) limitations affecting the reproduction of laboratory results at the mill. These considerations are briefly discussed in the next three paragraphs.

LABORATORY PULPING TESTS

Although the operation of the tests recorded in Tables 6 to 12 was standardized as far as possible, it was necessary to vary cooking conditions according to the character of the wood pulped. It is fully recognized that, with very little information available beforehand to guide the selection of the conditions, the cooks frequently failed to produce the best results. In such cases conclusions as to practical pulping values must be arrived at largely by a process of deduction based upon later and more exact knowledge of the factors involved. The figures shown in the tables represent, however, results obtained under specific selected conditions of operation. They make up the most comprehensive body of data that has been compiled with regard to the pulping of American species by the various chemical processes. They are presented in this bulletin as a matter of scientific record and for the possible guidance of future research.

CONDITIONS OF PULPING AND CHARACTER OF WOOD

For a number of years the laboratory has conducted special studies of spruce, loblolly pine, jack pine, and aspen in an effort to relate yield and quality of pulp to the conditions of pulping and to the characteristics of the wood itself. The results of these special studies have been published at intervals in Government bulletins or in the trade and technical journals. Many of the most important results have been obtained comparatively recently. Had the information been available at an earlier stage of the general study of American species, the conditions of pulping could have been selected so as to yield pulps in the laboratory more nearly equal, in both quantity and quality, to those now considered possible of realization on a commercial scale. In preparing the descriptive summaries of species, however, the aim has been to interpret the results of the pulping tests in the light of the more recently acquired knowledge and so arrive at reasonably accurate estimates of the practical pulping characteristics of the species studied.

COMMERCIAL ADAPTATION OF EXPERIMENTAL RESULTS

Laboratory equipment is designed to provide accurate control over a relatively wide variety of operating conditions. If it were possible to duplicate laboratory control on a commercial scale, laboratory results could, of course, be duplicated with mathematical accuracy. Such, however, is rarely the case. In mill practice unavoidable variations or irregularities are encountered, among which may be mentioned those in acid concentration, moisture content and quality of wood, temperature rise, pressure and wetness of steam, circulation of digester liquor, and end point of cook. It must be borne in mind also that the data recorded in the tables were obtained on a much smaller scale than obtains at the mill. It is true that wherever

opportunity has offered to carry on cooks in the mill under similar conditions, similar results have been obtained. Nevertheless there is always the possibility of divergence on account of the larger volumes of commercial cooks and the greater ratio of volume of digester to surface.

In estimating the pulping characteristics of the various woods, it has necessarily been assumed that the mill operator will take advantage of the best information available as to methods of operation. Due consideration has been given, however, to variations and irregularities of mill conditions, which militate against the highest yields and quality of pulp.

APPLICATION OF DATA TO OPERATING CONDITIONS

The oven-dry weight of the wood per cubic foot, green volume, given in the summaries, may be used as a factor in converting pulp yield by weight to yield per cord or any other unit of volume. Yields per cord may be determined by multiplying the yield of pulp based on weight by the oven-dry weight of the wood per cubic foot, and the product by the number of cubic feet solid wood obtained from a cord—due attention being given the character of the wood available from the particular species. The yields of pulp to be expected per cord or per thousand board feet are not directly stated as such because it was thought advisable that the reader exercise his own judgment in interpreting the data in this respect. The volume of solid wood per cord is an uncertain figure, which may vary from as little as 50 up to 100 cubic feet, according to the kind, shape, dimensions, soundness, and mechanical condition of the material. Rossed 2-foot spruce bolts of mixed diameters ranging from 6 to 14 inches contain slightly over 100 cubic feet per cord, and 100 cubic feet is assumed in figuring yields. Four-foot rossed bolts run 2 to 3 per cent less, 4-foot peeled bolts about 7 per cent less, and 4-foot rough bolts from 20 to 25 per cent less. The solid cubical content of mill waste varies enormously. Frequently 2 cords of mill waste will be found to yield only as much solid wood as 1 cord of 4-foot round bolts with the bark on.

The yield of oven-dry pulp is given in percentage of the oven-dry weight of the chips. Yields of less than 40 per cent are, in general, too low for profitable production, especially from woods lighter than 22 or 23 pounds to the cubic foot. Bleachability, discussed later, is a factor entering into calculations in this connection.

The physical characteristics of the species under consideration are not dwelt upon, such information being readily available in various works on forestry and on properties and uses of wood. They are, however, of especial importance in so far as they affect the ease with which the wood may be chipped and the bark removed; many species which may be easily pulped are rejected on account of the difficulty in handling them in the wood room.

In considering the suitability of a species in a given locality for pulp-making purposes, account should be taken of its growth habits, since the same species often varies greatly in properties with the latitude, altitude, character of soil, and other conditions of its environment.

Neither the durability of a species (i. e., resistance to decay) nor its susceptibility to insect attack is covered in this report, although

both are of immense importance from a practical standpoint, since it is customary to keep on hand at the mills at least one year's supply of pulp wood, and since much of the wood is in storage for considerably longer periods. Balsam fir, for example, shows admirable pulping qualities by any of the processes and yet is not well regarded by the industry, for the reason that it is very susceptible to both insect attack and decay. Although red alder is a wood excellently adapted to the manufacture of soda pulp, unless methods of handling can be devised whereby loss from its excessive susceptibility to decay may be avoided its use as a pulp wood will remain out of the question. Reference works on the pathological and entomological characteristics of various species are available and should be consulted in any particular case.

The fiber lengths stated are the averages of such measurements, often very limited in number, as have been made by the Forest Service or, where Forest Service measurements are not available, by other investigators. They offer only an indication of what may be expected from the species given. Since many of these measurements were made the significance of a further element, namely, the position of the fibers in the tree with reference to height, has been investigated in considerable detail. It has been found that the fiber length in one tree may vary from 0.8 to 7.65 millimeters⁴ or even from 0.3 to 8.6 millimeters.⁵ The length of the fibers undoubtedly affects the character of the pulp obtainable. The fineness of the fiber is also a very important characteristic.

Physical properties, however, considered alone, may lead to contradictory conclusions. Thus rather poor and tender pulps were obtained from redwood with a fiber length of 5½ millimeters, whereas an extremely tough and durable sheet was obtained from yellow birch sulphate pulp with a fiber length of only 1½ millimeters. The substance forming the fiber is of great importance in this respect and varies with different species as well as with different treatments.

The information on color and quality given in the summaries under the heading "Unbleached pulp" has particular reference to uses in which bleaching is not ordinarily practiced. Sulphite pulp, for instance, is often used without bleaching, as in conjunction with mechanical pulp in the manufacture of newsprint, and for that reason it must be light in color and free from shives. Sulphate pulp for wrapping paper is seldom bleached.

In other large uses, however, bleaching qualities are important. Exceptionally well-operated mills bleach spruce sulphite with as little as 10 per cent of bleaching powder of standard strength, but the average is well over 15 per cent. Some mills are using as much as 25 per cent on pulp obtained from the species available and yet are showing a profit.

Under the characteristics of sulphate pulps from the pines the bleach consumption in two stages is often shown. Tests indicated that in this case the consumption was only half that required in one stage and the color obtained was a purer white. Not all species were so tested, however, and the fact that the bleach requirement for two steps is not mentioned does not mean that better results

⁴ GERRY, E. MICROSCOPY OF PULPWOODS. Paper, Apr. 21, 1920.

⁵ LEE, H. N., and SMITH, E. M. DOUGLAS FIR FIBER, ETC. For. Quart., Dec., 1916,

might not occasionally be obtained by that procedure. It was found, however, that the advantages did not hold for sulphite.

In the soda process, the color of the unbleached pulp is not mentioned, since the pulp is almost invariably bleached before using.

In sulphate pulps from conifers strength is the outstanding requirement, although bleaching qualities are coming into account as the use of the bleached product increases.

With mechanical pulps color is the major consideration and sheet-forming qualities are important. Strength is also a desideratum, since the stronger the pulp the less sulphite is required to manufacture paper of specified strength. Many species otherwise suitable are not economically feasible for mechanical pulp on account of the power required in grinding. Power consumption may therefore be the controlling factor.

The power requirements given in the summaries for the various species apply to the production of ground wood of standard strength. On account of local conditions it may prove advisable to grind coarser or weaker pulps in order to use less power and gain in production and make up for the lower strength of the paper by using more sulphite.

When the establishment of a plant in an area new to the industry is in contemplation it is advisable to obtain pulping and paper-making tests on representative local samples of the species the use of which is intended. It is, of course, obvious that a complete survey of the locality should be made to ascertain the amounts of suitable species available, their rapidity of growth, the distribution and character of stands, etc. There should also be an economic survey of the supply of labor, living conditions, freight rates to centers of consumption, character and quantity of water available, and cost of fuel and power.

SUMMARIES BY SPECIES

Yields in all cases refer to the oven-dry weight of the pulp and are based on the oven-dry weight of the wood. Bleach requirements are expressed as percentages of the oven-dry weight of the pulp.

In the discussion of the coniferous species no mention is made of soda pulp, for the reason that strength and susceptibility to bleach, the most important qualities of the conifers, are better brought out by the sulphate than by the soda process.

1. THE SPRUCES

BLACK SPRUCE (*Picea mariana*)

Other names in use.—Double spruce and spruce pine. In the trade the wood is often mixed with red and white spruce and called eastern spruce.

Range.—Labrador to the MacKenzie River, and northwestward into Alaska; southward through Newfoundland, eastern Canada, Michigan, Wisconsin, Minnesota to central Pennsylvania, and in the northeastern mountains to northern Virginia.

Oven-dry weight per cubic foot, green volume.—23 pounds.

Fiber length.—2.6 mm.

By Sulphite Process

Reduces readily.

Unbleached pulp: Strong, of fine texture and excellent color, although occasionally somewhat pitchy; bleached easily to excellent white.

Yields: 45 to 50 per cent.

Bleach required: 10 to 20 per cent.

Uses to which pulp is suited: News, wrapping, book, high-grade printing, and bond paper.

By Sulphate Process

Reduces readily.

Unbleached pulp: Strong, of fine texture.

Yields: 45 to 50 per cent of strong pulp.

Bleaching properties probably similar to those of white spruce.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Reduces readily.

Pulp: Of excellent color and standard strength.

Power required: Comparable to that for white spruce.

Uses to which pulp is suited: Practically all uses requiring ground wood.

BLUE SPRUCE (*Picea pungens*, FORMERLY *P. parryana*)

Other names in use.—Parry's spruce, white spruce, silver spruce, and Colorado blue spruce.

Range.—Central Rocky Mountain region—Colorado, eastern Utah, southern and northwestern Wyoming, and northern New Mexico and Arizona.

Oven-dry weight per cubic foot, green volume.—23 pounds.

Fiber length.—2.8 mm.

By Sulphite Process

Reduces readily.

Unbleached pulp: Strong, of fine texture and excellent color; bleaches easily to excellent white.

Yields: 45 to 50 per cent.

Bleach required: 10 to 20 per cent.

Uses to which pulp is suited: News, wrapping, book, high-grade printing, and bond papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Strong, of fine texture.

Yields: 45 to 50 per cent of strong pulp; 38 to 43 per cent of pulp for bleaching.

Bleach required: 20 to 30 per cent in one stage, or 15 to 20 per cent in two stages.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Reduces readily.

Pulp: Of excellent color and standard strength.

Power required: Comparable to that for white spruce.

Uses to which pulp is suited: Practically all uses requiring ground wood.

ENGELMANN SPRUCE (*Picea engelmannii*)

Other names in use.—White spruce, balsam, mountain spruce, and silver spruce.

Range.—From southeastern and northern Arizona and southern New Mexico northward through the Rocky Mountain region to British Columbia, and westward to the eastern slopes of the Cascade Mountains in Oregon and Washington.

Oven-dry weight per cubic foot, green volume.—21 pounds,

Fiber length.—3 mm.

By Sulphite Process

Reduces readily.

Unbleached pulp: Strong, of fine texture and excellent color; bleaches easily to excellent white.

Yields: 45 to 50 per cent.

Bleach required: 10 to 20 per cent.

Uses to which pulp is suited: News, wrapping, book, high-grade printing, and bond papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Strong, of fine texture.

Yields: 45 to 50 per cent of strong pulp.

Bleaching properties probably similar to those of white spruce.

By Mechanical Process

Reduces readily.

Pulp: Of excellent color and standard strength.

Power required: Comparable to that for white spruce.

Uses to which pulp is suited: Practically all uses requiring ground wood.

NORWAY SPRUCE (*Picea abies*, FORMERLY *P. excelsa*)

Other names in use.—Spruce, fir, common spruce, and white fir.

Range.—From the Urals and Lapland to the Pyrenees and Alps. Planted in the eastern United States.

Oven-dry weight per cubic foot, green volume.—30 pounds.

Fiber length.—-----

By Sulphite Process

Reduces readily.

Unbleached pulp: Strong, of fine texture and excellent color; bleaches easily to excellent white.

Yields: 45 to 50 per cent.

Bleach required: 10 to 20 per cent.

Uses to which pulp is suited: News, wrapping, book, high-grade printing, and bond papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Strong, of fine texture.

Yields: 45 to 50 per cent of strong pulp; 38 to 43 per cent of pulp for bleaching.

Bleach required: 20 to 30 per cent in one stage, or 15 to 20 per cent in two stages.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Reduces readily.

Pulp: Of excellent color and standard strength.

Power required: Comparable to that for white spruce.

Uses to which pulp is suited: Practically all uses requiring ground wood.

RED SPRUCE (*Picea rubra*, formerly *P. rubens*)

Other names in use.—Yellow spruce. Trade names of the lumber are eastern spruce, West Virginia spruce, Canadian spruce, and Adirondack spruce.

Range.—Prince Edward Island southward to the coast of Massachusetts and through New England and New York and northern Pennsylvania to North Carolina and Tennessee (high mountains). Range imperfectly known. Over three-fourths of the present stand is in New England and New York.

Oven-dry weight per cubic foot, green volume.—24 pounds.

Fiber length.—3.7 mm.

By Sulphite Process

Reduces readily.

Unbleached pulp: Strong, of fine texture and excellent color, although occasionally somewhat pitchy; bleaches easily to excellent white.

Yields: 45 to 50 per cent.

Bleach required: 10 to 20 per cent.

Uses to which pulp is suited: News, wrapping, book, high-grade printing, and bond papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Strong, of fine texture.

Yields: 45 to 50 per cent of strong pulp.

Bleaching properties probably similar to those of white spruce.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Reduces readily.

Pulp: Of excellent color and standard strength.

Power required: Comparable to that for white spruce.

Uses to which pulp is suited: Practically all uses requiring round wood.

SITKA SPRUCE (*Picea sitchensis*)

Other names in use.—Tideland spruce and western spruce. Trade names of the lumber are Sitka spruce, yellow spruce, silver spruce, and west coast spruce.

Range.—Pacific coast region (extending inland about 50 miles) from the east end of Kadiak Island and Alaska to northern California.

Open-dry weight per cubic foot, green volume.—24 pounds.

Fiber length.—3.5 mm.

By Sulphite Process

Reduces readily.

Unbleached pulp: Strong and of excellent color, texture not quite so fine as that of white spruce; bleaches easily to excellent white.

Yields: 45 to 50 per cent.

Bleach required: 10 to 20 per cent.

Uses to which pulp is suited: News, wrapping, book, high-grade printing, and bond papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Strong, of fairly fine texture.

Yields: 45 to 50 per cent of strong pulp, 38 to 43 per cent of pulp for bleaching.

Bleach required: 20 to 30 per cent in one stage, or 15 to 20 per cent in two stages.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Reduces readily.

Pulp: Slightly grayish in color and of standard strength.

Power required: Comparable to that for white spruce.

Uses to which pulp is suited: Practically all uses requiring ground wood.

WHITE SPRUCE (*Picea glauca*, formerly, *P. canadensis*)

Other names in use.—Single spruce, cat spruce, skunk spruce, and blue spruce. The lumber, mixed with that of red spruce, is sold as eastern spruce.

Range.—Labrador to Hudson Bay and northward through Alaska to Bering Strait; southward in the Atlantic region to Maine, New Hampshire, Vermont, northern New York, Michigan, Wisconsin, and Minnesota.

Open-dry weight per cubic foot, green volume.—24 pounds.

Fiber length.—2.8 mm.

By Sulphite Process

Reduces readily.

Unbleached pulp: Strong, of fine texture and excellent color, although occasionally somewhat pitchy; bleaches easily to excellent white.

Yields: 45 to 50 per cent.

Bleach required: 10 to 20 per cent.

Uses to which pulp is suited: News, wrapping, book, high-grade printing, and bond papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Very strong, of fine texture.

Yields: 45 to 50 per cent of strong pulp, 38 to 43 per cent of pulp for bleaching.

Bleach required: 20 to 30 per cent in one stage, or 15 to 20 per cent in two stages.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Reduces readily.

Pulp: Of excellent color and standard strength.

Power required: 60 to 80 horsepower-days per ton (in actual commercial practice).

Uses to which pulp is suited: Practically all uses requiring ground wood.

2. THE PINES

LIMBER PINE (*Pinus flexilis*)

Other names in use.—White pine and Rocky Mountain pine.

Range.—Chiefly in Rocky Mountain region from Alberta and Montana to western Texas and New Mexico; westward in mountains of northern Arizona, Utah, Nevada, and California.

Oven-dry weight per cubic foot, green volume.—23 pounds.

Fiber length.—-----

By Sulphite Process

Does not reduce satisfactorily.

By Sulphate Process

Reduces readily.

Unbleached pulp; strong.

Yields: 45 to 50 per cent of strong pulp, 38 to 43 per cent of pulp for bleaching.

Bleach required: More than 20 per cent in one stage, or 15 to 20 per cent in two stages.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber boards.

By Mechanical Process

Reduces readily.

Pulp: Of good color and standard strength; somewhat pitchy.

Power required: 30 to 40 per cent more than for white spruce.

Uses to which pulp is suited: Limited chiefly by content of pitch.

PIÑON (*Pinus edulis*)

Other names in use.—Nut pine, piñon pine, and scrub pine.

Range.—From central Colorado southward to western Texas and western Oklahoma; westward to eastern Utah, and through New Mexico to northern, central, and southeastern Arizona; mountains of northern Mexico; Lower California.

Oven-dry weight per cubic foot, green volume.—31 pounds.

Fiber length.—2 mm.

By Sulphite Process

Reduces with difficulty. Too much resin for uniform cooking.

Unbleached pulp: Of fair strength and color. Somewhat shivy, often pitchy.

Yields: 40 to 45 per cent.

Bleach required: 20 to 30 per cent.

Uses to which pulp is suited: Possibly wrapping papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Fairly strong but somewhat shivy.

Yields: 40 to 45 per cent.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Probably too pitchy and knotty for grinding.

SUGAR PINE (*Pinus lambertiana*)

Other names in use.—California sugar pine and big pine.

Range.—Northwestern Oregon to southern and Lower California. The heaviest stands are found from Tulare to Eldorado counties in California.

Oven-dry weight per cubic foot, green volume.—23 pounds.

Fiber length.—4.1 mm.

By Sulphite Process

Reduces readily but unevenly.

Unbleached pulp: Of dull greenish-brown color and fair strength. Shivy and harsh.

Yields: 45 to 50 per cent.

Bleach required: 20 to 30 per cent.

Uses to which pulp is suited: Wrapping papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Very strong.

Yields: 45 to 50 per cent of strong pulp, 38 to 43 per cent of pulp for bleaching.

Bleach required: More than 20 per cent in one stage, or 15 to 20 per cent in two stages.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Probably similar to that of northern white pine.

NORTHERN WHITE PINE (*Pinus strobus*)

Other names in use.—White pine, eastern white pine, Wisconsin white pine, Minnesota white pine, Canadian white pine, and cork pine. The term "white pine" is also often applied in the trade to other species of pine the wood of which more or less resembles northern white pine in appearance and quality.

Range.—From Newfoundland to Lake Winnipeg and southward through the Lake States, the New England States, and the Appalachians as far south as northern Georgia.

Oven-dry weight per cubic foot, green volume.—23 pounds.

Fiber length.—4.1 mm.

By Sulphite Process

Reduces fairly readily but unevenly.

Unbleached pulp: Dull greenish brown in color; shivy and harsh.

Yields: 50 to 55 per cent.

Bleach required: More than 25 per cent.

Uses to which pulp is suited: Limited chiefly by dark color, shiviness, and harshness.

By Sulphate Process

Reduces readily.

Unbleached pulp: Very strong.

Yields: 45 to 50 per cent of strong pulp, 38 to 43 per cent of pulp for bleaching.

Bleach required: 20 to 30 per cent in one stage, or 15 to 20 per cent in two stages.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Reduces readily.

Pulp: of good color and standard strength, but pitchy.

Power required: 30 to 40 per cent more than for white spruce.

Uses to which pulp is suited: Limited chiefly by content of pitch.

JACK PINE (*Pinus banksiana*, formerly, *P. divaricata*)

Other names in use.—Scrub pine, gray pine, banksiana pine, and Hudson Bay pine.

Range.—Nova Scotia to northern New Hampshire and west through the Great Lakes and southern shores of Hudson Bay region to Great Bear Lake, Mackenzie River, and Rocky Mountains; south into northern Maine, northern New Hampshire, and Vermont, northern New York, Michigan, northern Illinois, Wisconsin, and central and southeastern Minnesota.

Oven-dry weight per cubic foot, green volume.—24 pounds.

Fiber length.—2.5 mm.

By Sulphite Process

Reduces readily but unevenly.

Unbleached pulp: Of good color and strength and fine texture, but shivy and pitchy.

Yields: 45 to 50 per cent.

Bleach required: 20 to 30 per cent.

Uses to which pulp is suited: Wrapping and printing papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Very strong and of fine texture.

Yields: 45 to 50 per cent of strong pulp, 38 to 43 per cent of pulp for bleaching.

Bleach required: More than 20 per cent in one stage, or 15 to 20 per cent in two stages.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Reduces fairly readily.

Pulp: Grayish in color but of standard strength; somewhat pitchy.

Power required: 40 to 50 per cent more than for white spruce.

Uses to which pulp is suited: Limited chiefly by poor color and presence of pitch.

LOBLOLLY PINE (*Pinus taeda*)

Other names in use.—Old-field pine, rosemary pine, sap pine, Virginia pine, and bastard pine. The lumber is usually mixed with that of short-leaf pine and is sold as short leaf or North Carolina pine.

Range.—South Atlantic and Gulf States from New Jersey, southern Delaware, eastern Maryland, and eastern West Virginia to central Florida; west to eastern Texas; northward into southwestern Oklahoma, Arkansas, and southern border of middle and west Tennessee.

Oven-dry weight per cubic foot, green volume.—30 pounds.

Fiber length.—3.0 mm.

By Sulphite Process

Reduces fairly readily.

Unbleached pulp: Slightly darker than white spruce sulphite and with a decided reddish-gray tone; of fair strength, with rather coarse fibers; probably pitchy.

Yields: 45 to 50 per cent.

Bleach required: 20 to 30 per cent.

Uses to which pulp is suited: Wrapping and printing papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Of good strength. Fibers long and rather coarse.

Yields: 45 to 50 per cent of strong pulp, 38 to 43 per cent of pulp for bleaching.

Bleach required: 20 to 30 per cent in one stage, or 10 to 20 per cent in two stages.

Uses to which pulp is suited: High-grade wrapping papers, fiber board, and book stock.

From 1 to 10 gallons (in case of selected materials) of turpentine per cord of wood cooked may be recovered from the digester relief.

By Mechanical Process

Reduces readily.

Pulp: Coarser and weaker than pulp from the spruces and inclined to be pitchy; color good from wood cut in the fall, poorer from wood cut in the spring.

Power required: 50 to 60 per cent more than for white spruce, to attain same strength of pulp.

Uses to which pulp is suited: Limited chiefly by poor color and presence of pitch.

LOGEPOLE PINE (*Pinus contorta*)⁶

Other names in use.—Scrub pine, knotty pine, Bolander's pine, Henderson's pine, tamarack, prickly pine, white pine, black pine, spruce pine, jack pine, and bird's-eye pine.

Range.—From Alaska (Yukon River) southward in the Pacific coast region to California (Mendocino County) and through interior British Columbia, the mountains of Washington and Oregon to California (Sierra Nevada to San Jacinto Mountains); plateau east of the Rocky Mountains (latitude 56°) and south through the Rocky Mountain Region to New Mexico and northern Arizona.

Oven-dry weight per cubic foot, green volume.—24 pounds.

Fiber length.—2.3 mm.

By Sulphite Process

Reduces readily.

Unbleached pulp: Of excellent color, fine fibered and very strong; probably somewhat pitchy; easily bleached.

Yields: 45 to 50 per cent.

Bleach required: 10 to 20 per cent.

Uses to which pulp is suited: News, wrapping, book, and high-grade printing papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Very strong.

Yields: 45 to 50 per cent of strong pulp.

Bleaching characteristics probably similar to those of jack pine.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Reduces readily.

Pulp: Of excellent color and standard strength.

Power required: 15 to 25 per cent more than for white spruce.

Uses: Practically all uses requiring ground wood.

NOTE.—The properties stated above apply to the lodgepole pine grown in the Rocky Mountain regions, which contains much less pitch than that grown in the lowlands and coastal regions. The pulping properties of the latter are similar to those of jack pine.

LONG-LEAF PINE (*Pinus palustris*)

Other names in use.—Long-leaf yellow pine, southern hard pine, southern heart pine, hill pine, Georgia pine, Florida pine, Texas yellow pine, North Carolina pitch pine, long-leafed pine, longstraw pine, southern yellow pine, fat pine. The lumber is usually called "pitch pine" in the export trade.

Range.—Atlantic coast region from southeastern Virginia to southern Florida and westward to eastern Texas; northward in Alabama to the northern part of the State, to northwestern Georgia, central and western Mississippi and western Louisiana almost to the northern border of the State.

Oven-dry weight per cubic foot, green volume.—34 pounds.

Fiber length.—3.7 mm.

By Sulphite Process

Long-leaf pine varies enormously in pitch content, and although selected trees might be used, it would be inadvisable to consider the use of this species on a commercial scale.

By Sulphate Process

Reduces readily.

Unbleached pulp: Strong, rather coarse, and very long fibered; requires special beater treatment to develop maximum strength. Strength is usually sacrificed to secure standard formation of sheet.

Yields: 45 to 50 per cent of strong pulp, 40 to 45 per cent of pulp for bleaching.

⁶ The Rocky Mountain form of this tree, upon which the following tests were made, was formerly and is still designated variously as *Pinus murrayana*, *P. contorta* var. *murrayana*, and *P. contorta* var. *latifolia*, the Pacific coast form being restricted to *P. contorta*. The Rocky Mountain form contains much less pitch than that from the lowlands and coastal regions. The properties of the lowland and coast form are approximately as given for jack pine.

Bleach required: 20 to 30 per cent in one stage, or 15 to 25 per cent in two stages.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

From 2 to 36 gallons (in the case of selected material) of turpentine and pine oil per cord of wood may be recovered from the digester relief.

By Mechanical Process

Not suitable for mechanical pulp on account of the high pitch content usually encountered.

MONTEREY PINE (*Pinus radiata*, formerly, *P. insignis*)

Other names in use.—Monterey pine is the name universally used for this species.

Range.—Occurs only in a few small areas near the coast of southern California.

Oven-dry weight per cubic foot, green volume.—29 pounds.

Fiber length.—-----

By Sulphite Process

Reduces fairly readily.

Unbleached pulp: Strong and of fair color; somewhat coarser than spruce sulphite pulp; fairly easily bleached.

Yields: 45 to 50 per cent.

Bleach required: 20 to 30 per cent.

Uses to which pulp is suited: Wrapping and printing papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Very strong, difficult to bleach.

Yields: 45 to 55 per cent of strong pulp.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Behavior probably similar to that of jack pine.

NORWAY PINE (*Pinus resinosa*)

Other names in use.—Red pine, hard pine, and northern pine.

Range.—From Nova Scotia to northern Ontario to southern Manitoba; southward through the Northern States to Massachusetts, southeastern Pennsylvania, northeastern Ohio, central Michigan, and northern Wisconsin; southern Wisconsin and northeastern Minnesota.

Oven-dry weight per cubic foot, green volume.—27 pounds.

Fiber length.—3.7 mm.

By Sulphite Process

Reduces fairly readily.

Unbleached pulp: Of good color, fairly fine-fibered and fairly strong; probably somewhat pitchy; fairly easily bleached.

Yields: 45 to 50 per cent.

Bleach required: 15 to 25 per cent.

Uses to which pulp is suited: Few. Limited chiefly by content of pitch.

By Sulphate Process

Reduces readily.

Unbleached pulp: Very strong.

Yields: 45 to 55 per cent of strong pulps, 40 to 45 per cent of pulp for bleaching.

Bleach required: 30 to 40 per cent.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Behavior probably similar to that of jack pine.

PITCH PINE (*Pinus rigida*)

Other names in use.—Hard pine, yellow pine, and sap pine.

Range.—From the coast of Maine to eastern Ontario, and southward in the Atlantic coast region to southern Virginia and along the mountains to northern Georgia; west to western New York, northeastern and northwestern Pennsylvania, eastern Ohio and Kentucky, and eastern Tennessee.

Oven-dry weight per cubic foot, green volume.—29 pounds.

Fiber length.—-----

By Sulphite Process

Reduces with difficulty.

Unbleached pulp: Too pitchy for commercial production; bleaches with some difficulty to a fairly satisfactory quality.

Yields: 45 to 50 per cent.

Bleach required: 30 to 40 per cent.

Uses to which pulp is suited: Limited chiefly by content of pitch.

By Sulphate Process

Reduces readily.

Unbleached pulp: Very strong; fibers longer and coarser than spruce.

Yields: 45 to 50 per cent of strong pulp, 38 to 43 per cent of pulp for bleaching.

Bleach: 20 to 30 per cent in one stage, or 15 to 25 per cent in two stages.

Uses to which pulp is suited: High-grade kraft wrapping papers, fiber board, and book stock.

Turpentine may be recovered from the digester relief in quantities warranting consideration.

By Mechanical Process

Probably too resinous for successful grinding.

POND PINE (*Pinus rigida serotina*, formerly, *P. serotina*)

Other names in use.—Spruce pine, bastard pine, pocoson pine, bay pine, black pine, marsh pine, and meadow pine.

Range.—Atlantic coast region from southern New Jersey and southeastern Virginia to east-central Florida and probably farther south; on the west coast of Florida from Pensacola to Citrus County and probably much farther south. Range imperfectly known.

Oven-dry weight per cubic foot, green volume.—31 pounds.

Fiber length.—-----

By Sulphite Process

Reduces readily.

Unbleached pulp: Of a reddish-gray tone, about the same color as hemlock sulphite, but fibers somewhat coarser. Probably somewhat pitchy. Bleaches easily.

Yields: 45 to 50 per cent.

Bleach required: 10 to 20 per cent.

Uses to which pulp is suited: Wrapping and printing papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Of good strength. Fibers are longer but coarser than those of spruce.

Yields: 45 to 50 per cent of strong pulp, 38 to 43 per cent of pulp for bleaching.

Bleach required: 20 to 30 per cent in one stage, or 10 to 20 per cent in two stages.

Uses to which pulp is suited: High-grade kraft wrapping papers, fiber board, and book stock.

From 1 to 10 gallons (in the case of selected material) of turpentine per cord of wood cooked may be recovered from the digester relief.

By Mechanical Process

Behavior probably similar to that of loblolly pine.

SAND PINE (*Pinus clausa*)

Other names in use.—Old-field pine, Florida spruce pine, scrub pine, and upland spruce pine.

Range.—Coast of Alabama and western Florida; east coast of Florida from St. Augustine to New River.

Oven-dry weight per cubic foot, green volume.—29 pounds.

Fiber length.—-----

By Sulphite Process

Reduces readily.

Unbleached pulp: Of good color; rather weak, with fibers of average fineness; probably somewhat pitchy; easily bleached.

Yields: 25 to 35 per cent (figures subject to modification by further investigation).

Bleach required: 10 to 20 per cent.

Uses to which the pulp is suited: Wrapping and printing papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Of fair strength.

Yields: 40 to 45 per cent.

Bleach required: Probably more than 20 per cent.

Uses to which the pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Behavior probably similar to that of jack pine.

SCOTCH PINE (*Pinus sylvestris*)

Other names in use.—Northern pine, Scots pine (Scotland), and Scotch fir (England).

Range.—Europe, northern Asia up to 700 feet above sea-level in the far north, 6,500 feet in southern Europe. Planted in eastern United States.

Oven-dry weight per cubic foot, green volume.—37 pounds (data from English sources).

Fiber length.—-----

By Sulphite Process

Reduces with difficulty and very unevenly.

Unbleached pulp: Of fair color but shivy; probably somewhat pitchy.

Yields: 45 to 50 per cent.

Bleach required: 20 to 30 per cent.

Uses to which pulp is suited: Few. Limited chiefly by content of pitch and shives.

By Sulphate Process

Reduces readily.

Unbleached pulp: Of good strength.

Yields: 40 to 45 per cent of strong pulp, 35 to 40 per cent of pulp for bleaching.

Bleach required: 20 to 30 per cent in one stage, 10 to 20 per cent in two stages.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

Turpentine may probably be recovered from the digester relief in quantities sufficient to warrant consideration.

By Mechanical Process

Behavior probably similar to that of jack pine.

VIRGINIA PINE (*Pinus virginiana*)

Other names in use.—Scrub pine, Jersey pine, and spruce pine. The lumber is often sold as North Carolina pine.

Range.—Mainly from central and southern New Jersey and central, southern, and western Pennsylvania to Georgia and northern Alabama; west into Ohio, southern Indiana, northeastern Mississippi, and middle Tennessee.

Oven-dry weight per cubic foot, green volume.—26 pounds.

Fiber length.—2.8 mm.

By Sulphite Process

Reduces readily.

Unbleached pulp: Of about the same color as hemlock sulphite, but with somewhat coarser fibers: probably pitchy.

Yields: Probably 45 to 50 per cent.

Bleach required: 20 to 30 per cent.

Uses to which pulp is suited: Wrapping and printing papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Of good strength; fibers longer and coarser than those of spruce.

Yields: 45 to 50 per cent of strong pulp, 38 to 43 per cent of pulp for bleaching.

Bleach required: 20 to 30 per cent in one stage, or 10 to 20 per cent in two stages.

Uses to which pulp is suited: High-grade kraft wrapping papers, fiber board, and book stock.

From 1 to 10 gallons (in the case of selected material) of turpentine per cord of wood may be recovered from the digester relief.

By Mechanical Process

Reduces readily.

Pulp: Coarser than spruce pulp, and pitchy.

Power required: 50 to 60 per cent more than for white spruce, to obtain the same strength of product.

Uses to which pulp is suited: Limited chiefly by content of pitch.

SHORT-LEAF PINE (*Pinus echinata*)

Other names in use.—Yellow pine, short-leaved pine, spruce pine, and bull pine. The lumber frequently goes under the name of North Carolina pine.

Range.—From southeastern New York to western Florida, and westward into West Virginia, southern Illinois, southern Missouri, eastern Oklahoma, and eastern Texas.

Oven-dry weight per cubic foot, green volume.—31 pounds.

Fiber length.—3.7 mm.

By Sulphite Process

Reduces fairly readily.

Unbleached pulp: Fairly strong; of the same color as hemlock sulphite, but with somewhat coarser fibers; probably pitchy.

Yields: 45 to 50 per cent.

Bleach required: 20 to 30 per cent.

Uses to which pulp is suited: Wrapping papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Fairly strong; fibers longer and coarser than those of spruce.

Yields: 45 to 50 per cent of strong pulp, 38 to 43 per cent of pulp for bleaching.

Bleach required: 20 to 30 per cent in one stage, or 10 to 20 per cent in two stages.

Uses to which pulp is suited: High-grade kraft wrapping papers, fiber board, and book stock.

From 1 to 10 gallons (in the case of selected materials) of turpentine per cord of wood may be recovered from the digester relief.

By Mechanical Process

Behavior similar to that of scrub pine.

Pulps obtained from wood cut in the fall have good color, those from wood cut in the spring considerably poorer color.

Uses to which pulp is suited: Limited chiefly by content of pitch.

SLASH PINE (*Pinus caribaea*, formerly, *P. cubensis* and *P. heterophylla*).

Other names in use.—Swamp pine, bastard pine, meadow pine, pitch pine, spruce pine, and saltwater pine.

Range.—Atlantic coast region (60 to 100 miles inland) from South Carolina to southern Florida; westward in the coast region of the Gulf States to eastern Louisiana.

Oven-dry weight per cubic foot, green volume.—37 pounds.

Fiber length.—-----

By Sulphite Process

Probably too resinous for consideration.

By Sulphate Process

Reduces readily.

Unbleached pulp: Strong; fibers rather long and coarse.

Yields: 45 to 50 per cent of strong pulp.

Bleach required: 20 to 30 per cent in one stage, or 10 to 20 per cent in two stages.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

From 2 to 30 gallons of turpentine and pine oil per cord of wood may be recovered from the digester relief.

On account of its rapid growth, the high quality of lumber obtained from it, its large yields of rosin, turpentine, and pine oil, and the ease with which it reduces to an easy-bleaching pulp, slash pine is worthy of consideration for replanting areas with a view to establishing a group of industries related to each other and dependent on a self-perpetuating supply of wood.

By Mechanical Process

Probably too resinous for consideration.

WESTERN YELLOW PINE (*Pinus ponderosa*)

Other names in use.—Yellow pine and bull pine. The lumber is sold under various trade names, including western pine, western soft pine, western white pine, California white pine, Oregon white pine, Washington white pine, Montana pine, Arizona soft pine, Arizona white pine, New Mexico white pine, Mexican white pine, British Columbia white pine, and ponderosa pine.

Range.—From British Columbia and the Black Hills of South Dakota southward in the Pacific and Rocky Mountain region to western Texas, northwestern Nebraska, and Mexico.

Oven-dry weight per cubic foot, green volume.—24 pounds.

Fiber length.—3.6 mm.

By Sulphite Process

Reduces fairly readily but unevenly.

Unbleached pulp: Dark in color, and shivvy.

Yields: 45 to 50 per cent.

Bleach required: Probably more than 20 per cent.

Uses to which pulp is suited: Limited chiefly by dark color and content of pitch and shives.

By Sulphate Process

Reduces readily.

Unbleached pulp: Very strong, the long, fine fibers having exceptionally good felting properties.

Yields: 45 to 50 per cent.

Bleach: Probably more than 25 per cent.

Probably enough turpentine may be recovered from the digester relief to warrant consideration.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Reduces fairly readily.

Pulp: Of satisfactory color and soft texture, but coarser than spruce pulp; probably pitchy.

Power required: 40 to 50 per cent more than for spruce, to obtain pulp of the same strength.

Uses to which pulp is suited: Limited by coarseness and pitchiness.

PEHUEN (*Araucaria aurocana*, formerly, *A. imbricata*)

Other names in use.—Native names for this species are pehuen and piño piñon. In English-speaking countries it is commonly referred to as Araucaria pine and monkey-puzzle.

Range.—Southern Brazil, Argentina, Chile.

Oven-dry weight per cubic foot, green volume.—33 pounds.

Fiber length.—-----

By Sulphite Process

Reduces readily.

Unbleached pulp: Light brown in color and of fair strength.

Yields: 45 to 55 per cent.

Bleach required: Probably more than 20 per cent.

Uses to which pulp is suited: Wrapping papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Of good strength, but somewhat softer than spruce sulphate.

Yields: 45 to 50 per cent.

Bleach required: 20 to 30 per cent in one stage, or 10 to 20 per cent in two stages.

Uses to which pulp is suited: Kraft wrapping papers and fiber board.

By Mechanical Process

Probably yields a fair grade of pulp of about the color of jack pine ground wood, with reasonable consumption of power.

3. THE FIRS

ALPINE FIR (*Abies lasiocarpa*)

Other names in use.—Sub-alpine fir, balsam, white fir, white balsam, Oregon balsam-tree, pumpkin tree, mountain balsam, black balsam, and balsam fir.

Range.—Rocky Mountain region from northern Arizona; southwestern New Mexico to Montana and Idaho, and westward through the mountains of Oregon and Washington and northward to Alaska: high ranges of British Columbia and Alberta.

Oven-dry weight per cubic foot, green volume.—21 pounds.

Fiber length.—-----

By Sulphite Process

Reduces readily.

Unbleached pulp: Of excellent color and strength, easily bleached.

Yields: 45 to 50 per cent.

Bleach required: 10 to 15 per cent.

Uses to which pulp is suited: News, wrapping, book, and high-grade printing papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Very strong.

Yields: 45 to 50 per cent of strong pulp, 40 to 45 per cent of pulp for bleaching.

Bleach required: 20 to 30 per cent.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Reduces readily.

Pulp: Of excellent color and standard strength.

Power required: 15 to 25 per cent more than for spruce.

Uses to which pulp is suited: Practically all uses requiring ground wood.

BALSAM FIR (*Abies balsamea*)

Other names in use.—Balsam, Canada balsam, Balm of Gilead fir, blister pine, fir pine, firtree, single spruce, silver pine, and she-balsam. The lumber is frequently called eastern fir in the market.

Range.—From Newfoundland and Labrador to Hudson Bay and northward to the Great Slave Lake region, and south to Pennsylvania (and along high mountains to Virginia), Michigan, Minnesota, and northeastern Iowa.

Oven-dry weight per cubic foot, green volume.—21 pounds.

Fiber length.—2.7 mm.

By Sulphite Process

Reduces readily under slightly milder conditions than are required for spruce.

Unbleached pulp: Of good color and excellent strength, but slighter softer, as a rule, than spruce sulphite; fairly easily bleached.

Yields: 45 to 50 per cent.

Bleached required: 15 to 25 per cent.

Uses to which pulp is suited: News, wrapping, book, and high-grade printing papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: very strong.

Yields: 45 to 50 per cent of strong pulp, 40 to 45 per cent of pulp for bleaching.

Bleach required: 20 to 30 per cent.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Reduces readily.

Pulp: Of excellent color and standard strength. On account of the susceptibility of this species to insect attack and decay, inferior pulps are often obtained which are not characteristic of the sound wood.

Power required: 15 to 25 per cent more than for white spruce.

Uses to which pulp is suited: Practically all uses requiring ground wood.

LOWLAND WHITE FIR (*Abies grandis*)

Other names in use.—White fir, silver fir, yellow fir, Oregon white fir, western white fir, great silver fir, and balsam fir.

Range.—Pacific coast region from Vancouver Island to western California and from Washington and Oregon to northern Idaho and Montana.

Oven-dry weight per cubic foot, green volume.—23 pounds.

Fiber length.—3.2 mm.

By Sulphite Process

Reduces readily.

Unbleached pulp: Of excellent color and strength; fibers somewhat coarser than spruce fibers; fairly easily bleached.

Yields: 45 to 55 per cent.

Bleach required: 15 to 25 per cent.

Uses to which pulp is suited: News, wrapping, book, and high-grade printing papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Very strong.

Yields: 45 to 50 per cent of strong pulp, 35 to 45 per cent of pulp for bleaching.

Bleach required: 20 to 30 per cent.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Reduces readily.

Pulp: Of excellent color.

Power required: 15 to 25 per cent more than for white spruce.

Uses to which pulp is suited: Practically all uses requiring ground wood.

NOBLE FIR (*Abies nobilis*)

Other names in use.—Red fir, larch, noble fir, and bigtree.

Range.—Western Washington and Oregon and northern California.

Oven-dry weight per cubic foot, green volume.—22 pounds.

Fiber length.—-----

By Sulphite Process

Reduces readily.

Unbleached pulp: Of excellent color and strength; fibers fine and tough; easily bleached.

Yields: 45 to 50 per cent.

Bleach required: 10 to 15 per cent.

Uses to which pulp is suited: News, wrapping, book, and high-grade printing papers.

By Sulphate Process

Reduces readily.

Yields: 45 to 50 per cent of strong pulp, 40 to 45 per cent of pulp for bleaching.

Bleach required: 20 to 30 per cent.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Reduces readily.

Pulp: Of excellent color and standard strength.

Power required: 20 per cent less than for spruce.

Uses to which pulp is suited: Practically all uses requiring ground wood.

RED FIR (*Abies magnifica*)

Other names in use.—California red-bark fir and California red fir.

Range.—California (Sierra Nevada Mountains) and northward in the Cascade Mountains of southern Oregon.

Oven-dry weight per cubic foot, green volume.—23 pounds.

Fiber length.—-----

By Sulphite Process

Reduces fairly readily.

Unbleached pulp: Very strong, darker than spruce sulphite but lighter than hemlock sulphite; fibers fairly fine; fairly easily bleached.

Yields: 45 to 50 per cent.

Bleach required: 15 to 25 per cent.

Uses to which pulp is suited: News, wrapping, book, and high-grade printing papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Very strong.

Yields: 45 to 50 per cent of strong pulp, 38 to 43 per cent of pulp for bleaching.

Bleach required: More than 30 per cent.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Reduces readily.

Pulp: Color slightly reddish; of standard strength.

Power required: 15 to 25 per cent more than for spruce.

Uses to which pulp is suited: Practically all uses requiring ground wood, except as limited by dark color.

SILVER FIR (*Abies amabilis*)

Other names in use.—Red fir, red silver fir, fir, and larch.

Range.—From southeastern Alaska to Vancouver Island and British Columbia and southward in the Cascade Mountains to northern Oregon; also in the coast mountains of Washington and Oregon.

Oven-dry weight per cubic foot, green volume.—22 pounds.

Fiber length.—-----

By Sulphite Process

Reduces readily.

Unbleached pulp: Of excellent color and strength; fairly easily bleached.

Yields: 45 to 50 per cent.

Bleached required: 20 to 30 per cent.

Uses to which pulp is suited: News, wrapping, book, and high-grade printing papers.

By Sulphate Process

Reduced readily.

Unbleached pulp: Very strong, long fibered.

Yields: 48 to 53 per cent of strong pulp.

Bleaching properties probably similar to those of noble fir.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Behavior similar to that of white spruce.

WHITE FIR (*Abies concolor*)

Other names in use.—Balsam fir, silver fir, white balsam, bastard pine, and blue fir.

Range.—Southwestern Oregon to southern California; northern Arizona and New Mexico to Colorado and northern Utah.

Oven-dry weight per cubic foot, green volume.—22 pounds.

Fiber length.—3.5 mm.

By Sulphite Process

Reduces readily.

Unbleached pulp: Of excellent color and strength; fibers larger and somewhat coarser than spruce fibers; easily bleached.

Yields: 45 to 50 per cent.

Bleach required: 10 to 15 per cent.

Uses to which pulp is suited: News, wrapping, book, and high-grade printing papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Very strong.

Yields: 48 to 53 per cent of strong pulp, 38 to 43 per cent of pulp for bleaching.

Bleach required: 20 to 30 per cent.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Reduces readily.

Pulp: Of excellent color and standard strength. Pulp from young trees are usually of better quality than from old trees on account of the susceptibility of this species to heart rot.

Power required: 15 to 20 per cent more than for white spruce.

Uses to which pulp is suited: Practically all uses requiring ground wood.

DOUGLAS FIR (*Pseudotsuga taxifolia*)

Other names in use.—Red fir, yellow fir, Oregon pine, Douglas spruce, red pine, Puget Sound pine, Santiam quality fir, and red spruce.

Range.—From the Rocky Mountain region (in the United States) and northward to central British Columbia; westward to the Pacific coast and southward into northern Mexico and the mountains of western Texas. Over one-half of the present stand is in western Washington and Oregon.

Oven-dry weight per cubic foot, green volume.—28 pounds.

Fiber length.—4.4 mm.

By Sulphite Process

Reduces with difficulty on account of the pitchy character of the wood.

Unbleached pulp: Of fair strength and poor color; probably somewhat pitchy.

Yields: 45 to 50 per cent.

Bleach required: 20 to 25 per cent.

Uses to which the pulp is suited: Limited chiefly by poor color and content of pitch.

By Sulphate Process

Reduces readily.

Unbleached pulp: Fairly strong.

Yields: 45 to 50 per cent.

Probably enough turpentine can be recovered from the digester relief to warrant consideration.

Uses to which pulp is suited: Kraft wrapping papers and fiber board which do not require maximum strength.

By Mechanical Process

Too resinous for grinding.

4. HEMLOCKS AND OTHER CONIFERS

CAROLINA HEMLOCK (*Tsuga caroliniana*)

Other names in use.—Spruce pine, hemlock, and hemlock spruce.

Range.—Mountains of southwestern Virginia and western North Carolina to northern Georgia; very local.

Oven-dry weight per cubic foot, green volume.—30 pounds.

Fiber length.—-----

By Sulphite Process

Reduces fairly readily.

Unbleached pulp: Slightly lighter in color than eastern hemlock sulphite, but otherwise similar; fairly easily bleached.

Yields: 45 to 50 per cent.

Bleach required: 20 to 30 per cent.

Uses to which pulp is suited: Same as for eastern hemlock.

By Sulphate Process

Reduces readily.

Unbleached pulp: Strong.

Yields: 45 to 50 per cent of strong pulp, 35 to 40 per cent of pulp for blenching.

Bleach: More than 30 per cent.

Uses to which pulp is suited: Same as for eastern hemlock.

By Mechanical Process

Behavior probably similar to that of eastern hemlock.

EASTERN HEMLOCK (*Tsuga canadensis*)

Other names in use.—Hemlock, hemlock spruce, and spruce pine.

Range.—Nova Scotia to eastern Minnesota, to southwestern Wisconsin, southern Michigan, and Indiana; southward in the Atlantic coast region to Delaware and Maryland, and southward along the mountains to northern Alabama and Georgia.

Oven-dry weight per cubic foot, green volume.—24 pounds.

Fiber length.—3 mm.

By Sulphite Process

Reduces fairly readily.

Unbleached pulp: Very strong, as compared with spruce sulphite; darker in color and with a decided reddish-gray tone; fibers somewhat coarser and more readily hydrated in the beater; fairly easily bleached.

Yields: 40 to 45 per cent.

Bleach required: 15 to 25 per cent.

Uses to which pulp is suited: News, wrapping, book, and high-grade printing papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Very strong.

Yields: 45 to 50 per cent of strong pulp, 40 to 45 per cent of pulp for bleaching.

Bleach required: 20 to 30 per cent in one stage, or 10 to 20 per cent in two stages.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Reduces fairly readily.

Pulp: Slightly reddish in color, somewhat brittle.

Power required: 50 to 60 per cent more than for white spruce, to obtain standard strength.

Uses to which pulp is suited: As partial substitute for white spruce ground wood.

WESTERN HEMLOCK (*Tsuga heterophylla*)

Other names in use.—Hemlock, western hemlock, hemlock spruce, and Alaska pine. In the lumber trade the wood is often called West coast and Pacific hemlock. In England it is largely known as western hemlock fir and Prince Albert's fir.

Range.—From southeastern Alaska to northern Idaho and northwestern Montana, and southward in Washington and western Oregon to northwestern California. The best stands are found in the coast region and through the Cascade Mountains at an elevation of 1,500 to 3,500 feet.

Oven-dry weight per cubic foot, green volume.—23 pounds.

Fiber length.—2.7 mm.

By Sulphite Process

Reduces readily, more like spruce than eastern hemlock.

Unbleached pulp: Tough and strong; much lighter in color and finer in texture than eastern hemlock.

Yield: 45 to 50 per cent.

Bleach required: 15 to 25 per cent.

Uses to which pulp is suited: News, wrapping, book, and high-grade printing papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Very strong and tough.

Yields 45 to 50 per cent of strong pulp.

Bleaching properties probably similar to those of eastern hemlock.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Reduces readily.

Pulp: Of excellent color and standard strength.

Power required: 10 to 15 per cent more than for spruce.

Uses to which pulp is suited: Practically all uses requiring ground wood.

TAMARACK (*Larix laricina* FORMERLY *L. americana*)

Other names in use.—Larch, hackmatack, and American larch.

Range.—From Newfoundland and Labrador northward, through the Hudson Bay region, to the Mackenzie River and reappearing in Alaska between Cook Inlet and the Yukon River; southward in the East to northern and eastern Pennsylvania, western Maryland, northeastern West Virginia, northern Ohio, Indiana, and Illinois, and northeastern Minnesota; in western Canada extending southward along the eastern base of the Rockies.

Oven-dry weight per cubic foot, green volume.—31 pounds.

Fiber length.—2.6 mm.

By Sulphite Process

Reduces with difficulty.

Unbleached pulp: Brash, shivy, and dark in color; fairly easily bleached to satisfactory product.

Yields: 40 to 45 per cent.

Bleach required: 15 to 25 per cent.

Uses to which pulp is suited: Low-grade wrapping papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Very strong and tough.

Yields: 45 to 50 per cent of strong pulp, 35 to 40 per cent of pulp for bleaching.

Bleach required: 25 to 30 per cent.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Reduces readily.

Pulp: Light grayish green in color.

Power required: 40 to 50 per cent more than for white spruce to obtain standard strength.

Uses to which pulp is suited: Practically all uses requiring ground wood.

WESTERN LARCH (*Larix occidentalis*)

Other names in use.—Larch, tamarack, hackmatack, red American larch, and western tamarack. The lumber is variously called western larch, Montana larch, Oregon larch, and British Columbia tamarack.

Range.—Southern British Columbia and south in the Cascade Mountains to the Columbia River, and to western Montana; also in southeastern Washington, northeastern Oregon, and northern Idaho.

Oven-dry weight per cubic foot, green volume.—28 pounds.

Fiber length.—2.6 mm.

By Sulphite Process

Reduces with difficulty and very unevenly.

Unbleached pulp: Brash, shivv, and dark in color; bleaches to fairly satisfactory product.

Yields: 40 to 45 per cent of pulp for bleaching.

Bleach required: 15 to 25 per cent.

Uses to which pulp is suited: Low-grade wrapping papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Very strong.

Yields: 45 to 50 per cent of strong pulp.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Reduces with difficulty.

Pulp: Rather coarse, decidedly brown in color.

Power required: Two and half times more than for white spruce, to obtain standard strength.

Uses to which pulp is suited: Limited by poor color and coarseness.

INCENSE CEDAR (*Libocedrus decurrens*)

Other names in use.—Cedar, post cedar, bastard cedar, and California post cedar.

Range.—From northwestern Oregon southward through California into Mexico and Lower California. The commercial range is confined largely to the mountains of northern California and southern Oregon.

Oven-dry weight per cubic foot, green volume.—23 pounds.

Fiber length.—2 mm.

By Sulphite Process

Reduces fairly readily.

Unbleached pulp: Very dark in color; bleaches with difficulty.

Yields: 40 to 45 per cent.

Bleach required: More than 35 per cent.

Uses to which pulp is suited: Limited chiefly by poor color.

By Sulphate Process

Reduces readily. Best results obtained at cooking temperatures corresponding to steam pressures below 80 pounds per square inch.

Unbleached pulp: Fine fibered and very strong, but strength easily impaired by too high temperatures during cooking.

Yields: 40 to 45 per cent of strong pulp, 35 to 40 per cent of pulp for bleaching.

Bleach required: More than 30 per cent.

Uses to which pulp is suited: Kraft wrapping papers and fiber board.

By Mechanical Process

Pulp too dark for ordinary ground-wood uses.

PORT ORFORD CEDAR (*Chamaecyparis lawsoniana*)

Other names in use.—Lawson's cypress, Oregon cedar, ginger pine, and white cedar.

Range.—Pacific coast region from southwestern Oregon to northwestern California, extending inland about 40 miles. The bulk of the timber of commercial importance is confined to a strip 20 to 25 miles wide along the Pacific coast in Coos and Curry Counties, Oreg.

Oven-dry weight per cubic foot, green volume.—26 pounds.

Fiber length.—2.6 mm.

By Sulphite Process

Reduces fairly readily.

Unbleached pulp: Strong, fine fibered; rather difficult to bleach.

Yields: 45 to 55 per cent.

Bleach required: 25 to 30 per cent.

Uses to which pulp is suited: Wrapping papers and some print papers.

By Sulphate Process

Reduces readily. Best results obtained at cooking temperatures corresponding to steam pressures below 80 pounds per square inch.

Unbleached pulp: Very strong, but strength easily impaired by too high temperatures during cooking.

Yields: Not fully determined; possibly 40 to 45 per cent.

Bleach required: 25 to 30 per cent.

Uses to which pulp is suited: Kraft wrapping papers and fiber board.

By Mechanical Process

Probably unsuited to grinding because of color and nature of the wood.

SOUTHERN WHITE CEDAR (*Chamaecyparis thyoides*)

Other names in use.—White cedar, swamp cedar, post cedar, and juniper.

Range.—Atlantic coast region from southern Maine to northern Florida westward to Mississippi (Pearl River).

Oven-dry weight per cubic foot, green volume.—20 pounds.

Fiber length.—2.1 mm.

By Sulphite Process

Pulping characteristics probably similar to those of Port Orford cedar.

By Sulphate Process

Reduces readily. Best results obtained at cooking temperatures corresponding to pressures below 80 pounds per square inch.

Unbleached pulp: Very strong, but strength easily impaired by too high temperatures during cooking.

Yields: 45 to 50 per cent of strong pulp, 38 to 43 per cent of pulp for bleaching.

Bleach required: 20 to 30 per cent.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Probably reduces readily to satisfactory pulps with reasonable power consumption.

EASTERN RED CEDAR (*Juniperus virginiana*)

Other names in use.—Cedar, juniper, and savin. Trade names for the wood are eastern red cedar and Tennessee red cedar.

Range.—Nova Scotia and New Brunswick to Georgia (coast), southern Alabama and Mississippi; west in Ontario (Georgian Bay) to eastern North and South Dakota, southern Michigan, eastern Nebraska and Kansas, southeastern Oklahoma, southwestern Arkansas, and eastern Texas.

Oven-dry weight per cubic foot, green volume.—27 pounds.

Fiber length.—2.8 mm.

By Sulphite Process

Wood too oily for reduction to satisfactory pulp.

By Sulphate Process

Reduces readily. Cooking temperatures corresponding to 80 pounds steam pressure should not be exceeded. The knotty character of the wood and the smallness of the average bolt would offer difficulties in the wood room.

Unbleached pulp: Strength easily impaired by too high cooking temperatures; practically impossible to bleach.

Yields: 40 to 45 per cent.

From 5 to 10 gallons of cedar oil per cord of wood may be recovered from the digester relief.

Uses to which pulp is suited: Kraft wrapping papers.

By Mechanical Process

Wood too dark in color, too oily, and too knotty for the production of satisfactory pulp.

WESTERN RED CEDAR (*Thuja plicata*)

Other names in use.—Red cedar, canoe cedar, arborvitae, shinglewood, gigantic, cedar, Pacific red cedar, and western cedar.

Range.—From the coast of southern Alaska to northern California; eastward through British Columbia and northern Washington to northern Idaho and Montana.

Oven-dry weight per cubic foot, green volume.—19 pounds.

Fiber length.—3.8 mm.

By Sulphite Process

Pulp: Dark in color, shivy, and practically impossible to bleach.

Uses to which pulp is suited: Limited chiefly by poor color and shiviness.

By Sulphate Process

Reduces readily. It is probable that the digester pressure during cooking should not exceed 90 pounds per square inch.

Unbleached pulp: Very strong.

Yields: 40 to 45 per cent.

Uses to which pulp is suited: High-grade kraft wrapping papers and fiber board.

By Mechanical Process

Wood too dark for production of satisfactory pulp.

SOUTHERN CYPRESS (*Taxodium distichum*)

Other names in use.—Cypress, bald cypress, red cypress, black cypress, white cypress, yellow cypress, and Gulf cypress.

Range.—From southern Delaware southward in the Atlantic coast region to southern Florida; westward in the Gulf Coast region to western Texas, and northward through Louisiana to Oklahoma, Arkansas, northern and western Mississippi and Tennessee, southeastern Missouri, western Kentucky, southern Illinois, and southwestern Indiana. The greater part of the supply of this timber is in Louisiana and Florida.

Oven-dry weight per cubic foot, green volume.—27 pounds.

Fiber length.—3.3 mm.

By Sulphite Process

Reduces with difficulty.

Unbleached pulp: Fairly strong but very dark in color; difficult to bleach.

Yields: 45 to 50 per cent.

Bleach required: 25 to 35 per cent.

Uses to which pulp is suited: Limited chiefly by poor color.

By Sulphate Process

Reduces readily.

Unbleached pulp: Soft and long fibered; required careful beating to develop satisfactory strength.

Yields: 50 to 55 per cent of strong pulp, 35 to 40 per cent of pulp for bleaching.

Bleach required: More than 25 per cent.

Uses to which pulp is suited: Kraft wrapping papers and fiber board.

By Mechanical Process

Not suited to ground-wood production because of color.

REDWOOD (*Sequoia sempervirens*)

Other names in use.—Sequoia, California redwood, and coast redwood.

Range.—From the southern borders of Oregon southward in the Pacific coast region 20 to 30 miles inland) to about 100 miles south of San Francisco.

Oven-dry weight of the wood per cubic foot, green volume.—23 pounds.

Fiber length.—5.5 mm.

By Sulphite Process

Reduces readily but unevenly.

Unbleached pulp: Fairly strong but brash, shivy, dark in color, and practically impossible to bleach.

Yields: About 50 per cent.

Uses to which pulp is suited: Low-grade wrapping papers.

By Sulphate Process

Reduces readily.

Unbleached pulp: Fairly strong; fibers very long but soft and tender. Best results are obtained when chips are leached before cooking and 10 to 20 per cent of their weight extracted as a tanninlike dark red coloring substance.

Yields: 35 to 40 per cent.

Bleach required: More than 30 per cent, even when yield is reduced to 30 per cent.

Uses to which pulp is suited: No. 2 kraft wrapping paper; with very careful beating, possibly No. 1 kraft.

Both the specific gravity of the wood and the percentage yield by weight are low and combine to reduce the yield per cord below that of the coniferous woods generally pulped.

By Mechanical Process

Wood too dark for production of satisfactory pulp.

5. HARDWOODS—DIFFUSE-POROUS

Possible uses: Reference is directed to page 20 for a discussion of the uses of hardwood pulps as a group. Individual species differ as to the ease or difficulty with which pulps of satisfactory quality can be produced rather than as to specific uses for which they may be suited. Therefore no discussion of specific uses of pulps from the individual species will be attempted in the summaries.

Sulphate process: Practically all American hardwoods can be pulped by the sulphate process as readily as by the soda process. The sulphate pulps usually bleach with less bleaching powder than soda pulps; otherwise the two classes show practically no difference in quality. The soda process, however, since it was established earlier than the sulphate and operates with greater freedom from offensive odors, has remained almost without challenge for the pulping of hardwoods. Therefore the sulphate process will be referred to only incidentally in this section.

ASPEN (*Populus tremuloides*)

Other names in use.—Quaking asp, American aspen, aspen leaf, white poplar, trembling poplar, American poplar, poplar, popple, trembling aspen, and quaking aspen.

Range.—Southern Labrador to Hudson Bay (southern shores) and northward to the Mackenzie River (near mouth); southward through Northeastern

United States and in the mountains to southern Kentucky, to northern Ohio, Indiana and Illinois, eastern and central Iowa and northern Missouri.

Oven-dry weight per cubic foot, green volume.—23 pounds.

Fiber length.—1 mm.

By Sulphite Process

Reduces readily.

Unbleached pulp: Of excellent color; usually contains small black specks, which, however, disappear on bleaching: easily bleached.

Yields: 45 to 50 per cent.

Bleach required: 10 to 15 per cent.

By Soda Process

Reduces fairly readily.

Unbleached pulp: Bleaches easily.

Yields: 45 to 50 per cent.

Bleach required: 10 to 15 per cent.⁷

By Mechanical Process

Aspen is readily reduced to mechanical pulp, yielding 85 to 86 per cent of standard strength with approximately three times as much power as is required for spruce. Upon the introduction of the ground-wood process aspen came to be used to a considerable extent on account of the light color of the pulp. Spruce has now supplanted it because much less power is required and pulp of greater strength and better felting properties is obtained.

BALSAM POPLAR (*Populus balsamifera*)

Other names in use.—Balsam, balm of Gilead, cottonwood, and faca mahac.

Range.—Coast of Alaska and valley of Mackenzie River to Hudson Bay and Labrador; southward to northern New England and New York, central Michigan and Minnesota, northern North Dakota, western South Dakota, northwestern Nebraska, Colorado, northern Montana, Idaho, Oregon, and Nevada.

Oven-dry weight per cubic foot, green volume.—26 pounds.

Fiber length.—1 mm.

By Sulphite Process

Reduces with exceptional ease.

Unbleached pulp: Of excellent color; not contaminated with black specks characteristic of aspen; very easily bleached.

Yields: 45 to 50 per cent.

Bleach required: 5 to 10 per cent.

By Soda Process

Reduces readily.

Unbleached pulp: Fairly easily bleached.

Yields: 45 to 50 per cent.

Bleach required: 15 to 20 per cent.

By Mechanical Process

Behavior probably similar to that of aspen.

COTTONWOOD

Other names in use.—For the purposes of this bulletin both eastern cottonwood (*Populus deltoides*) and southern cottonwood (*P. deltoides virginiana*) are included under the name "cottonwood."

Range.—The range of eastern cottonwood is commonly recognized as northwestern Vermont, through western New York, eastern border of Pennsylvania, and central Maryland; central-eastern Mississippi. The complete range is imperfectly known. Southern cottonwood ranges from Quebec and Lake Champlain southward through western New-England to Florida; westward to southern Minnesota, the Dakotas, eastern Nebraska, Kansas, Oklahoma, and Texas.

Oven-dry weight per cubic foot, green volume.—23 pounds.

Fiber length.—1.3 mm.

⁷About 7 to 12 per cent when cooked by sulphate process to yields indicated.

By Sulphite Process

Pulping properties probably similar to those of aspen, but pulp less contaminated with black specks.

*By Soda Process*⁸

Reduces readily.

Unbleached pulp: Fibers longer than those from aspen; fairly easily bleached.

Yields: 45 to 50 per cent.

Bleach required: 15 to 20 per cent.

By Mechanical Process

Behavior similar to that of aspen.

LARGETOOTH ASPEN (*Populus grandidentata*)

Other names in use.—Poplar, largetoothed poplar, large poplar, white poplar, popple, and large American aspen.

Range.—Nova Scotia, New Brunswick, southern Quebec, and Ontario to northern Minnesota, and northeastern North Dakota; southward to Pennsylvania, Ohio, and Iowa, and along the Alleghany Mountains to North Carolina, central Kentucky and Tennessee.

Oven-dry weight per cubic foot, green volume.—22 pounds.

Fiber length.—1.1 mm.

By Sulphite Process

Reduces readily.

Unbleached pulp: Of excellent color; bleaches fairly readily.

Yields: 45 to 50 per cent.

Bleach required: 15 to 20 per cent.

By Soda Process

Reduces readily.

Unbleached pulp: Bleaches fairly readily.

Yields: 40 to 45 per cent.

Bleach required: 15 to 20 per cent.

By Mechanical Process

Behavior probably similar to that of aspen.

YELLOW POPLAR (*Liriodendron tulipifera*)

Other names in use.—Tulip poplar, tulip-tree, whitewood, poplar, white poplar, blue poplar, and hickory poplar.

Range.—From Rhode Island to southwestern Vermont and west to Lake Michigan; south to northern Florida, southern Alabama and Mississippi; west of Mississippi River in northeastern Louisiana, southeastern Missouri, and northeastern Arkansas.

Oven-dry weight per cubic foot, green volume.—26 pounds.

Fiber length.—1.8 mm.

By Sulphite Process

Reduces readily.

Unbleached pulp: Of poor color, though less contaminated with black specks than is aspen sulphite; difficult to bleach.

Yields: 45 to 50 per cent.

Bleach required: 20 to 25 per cent.

By Soda Process

Reduces fairly readily.

Unbleached pulp: Stronger than aspen pulp; fairly easily bleached.

Yields: 40 to 45 per cent.

Bleach required: 15 to 20 per cent.⁹

⁸ Tests were also made on Norway poplar (*Populus canadensis eugenei*, a hybrid) which behaves like cottonwood. Norway poplar is believed to be a cross between *P. deltoides* and *P. nigra italica*—a European species—and the resultant hybrid has been planted extensively in this country.

⁹ About 12 to 18 per cent when cooked by sulphate process to yields indicated.

By Mechanical Process

Behavior probably similar to that of aspen, but slightly less power required for pulp of standard strength.

BASSWOOD (*Tilia glabra*, formerly *Tilia Americana*)

Other names in use.—American linden, linn, lime tree, and whitewood.

Range.—New Brunswick to Lake Superior (eastern shores) and to Lake Winnipeg (southern shores) and the Assiniboine River; south to Pennsylvania, Ohio, through Michigan, Indiana, and Illinois and eastern Nebraska to Missouri.

Oven-dry weight per cubic foot, green volume.—21 pounds.

Fiber length.—1.1 mm.

By Sulphite Process

Unbleached pulp: Very shivy, incapable of satisfactory bleaching.

By Soda Process

Reduces readily.

Unbleached pulp: Fairly easy to bleach.

Yields: 45 to 50 per cent.

Bleach required: 20 to 25 per cent.¹⁰

By Mechanical Process

Behavior probably similar to that of aspen.

BLACK WILLOW (*Salix nigra*)

Other names in use.—Swamp willow and willow. The lumber is usually called willow.

Range.—Southern New Brunswick, Quebec and Ontario to Georgia and central Alabama; west to southeastern North Dakota, eastern South Dakota, Nebraska, Kansas, Oklahoma, southwestern Arkansas, western Texas.

Oven-dry weight per cubic foot, green volume.—21 pounds.

Fiber length.—0.8 mm.

By Sulphite Process

Reduces readily.

Unbleached pulp: Of excellent color, somewhat contaminated with black specks; fairly easily bleached.

Yields: 50 to 55 per cent.

Bleach required: 15 to 20 per cent.

By Soda Process

Reduces readily.

Unbleached pulp: Fairly easy to bleach.

Yields: 45 to 50 per cent.

Bleach required: 15 to 20 per cent.

By Mechanical Process

Behavior probably similar to that of aspen.

SANDBAR WILLOW (*Salix longifolia*, formerly, in part, *S. fluviatilis*)

Other names in use.—Long-leaved willow, narrow-leaved willow, and river-bank willow.

Range.—Quebec to Athabasca and southward through western New England to Virginia; westward to Colorado and southern Texas.

Oven-dry weight per cubic foot, green volume.—23 pounds.

Fiber length.—0.7 mm.

By Sulphite Process

Reduces easily.

Unbleached pulp: Of poor color; bleaches easily.

Yields: 45 to 50 per cent.

Bleach required: 5 to 10 per cent.

¹⁰ About 10 to 13 per cent when cooked by sulphate process to yields indicated.

By Soda Process

Reduces readily.

Unbleached pulp: Bleaches with difficulty.

Yields: 40 to 45 per cent.

Bleach required: 25 to 30 per cent.

By Mechanical Process

Behavior probably similar to that of aspen.

RED ALDER (*Alnus rubra*)

Other names in use.—Alder and western alder.

Range.—From southeastern Alaska to southern California.

Oven-dry weight per cubic foot, green volume.—23 pounds.

Fiber length.—1.2 mm.

By Sulphite Process

Not determined.

By Soda Process

Reduces readily.

Unbleached pulp: Fairly easy to bleach.

Yields: 40 to 45 per cent.

Bleach required: 20 to 25 per cent.¹¹

Red alder is much more susceptible to decay than ordinary pulp woods.

By Mechanical Process

Behavior probably similar to that of aspen.

BALSA (*Ochroma lagopus*)

Other names in use.—Balsa and balsa wood are the English and the commoner trade names for the wood. Common native names are lanero and lanillo in Cuba, bombast mahoe in Jamaica, and guano in Spanish Honduras.

Range.—Tropical America, Cuba, Jamaica, and Porto Rico.

Oven-dry weight per cubic foot, green volume.—7 pounds.

Fiber length.—1.33 mm.

By Sulphite Process

Not determined.

By Sulphate Process

Reduces readily.

Unbleached pulp: Fairly easily bleached.

Yield: 55 to 60 per cent. The lightness of the wood makes the yield on the volume basis extremely low.

Bleach required: 25 to 30 per cent.

Uses to which pulp is suited: Balsa is probably of no commercial value as a pulp wood because of the extremely low yield per unit of volume.

By Mechanical Process

Not determined.

BOX ELDER (*Acer negundo*)

Other names in use.—Ash-leaved maple and three-leaved maple.

Range.—From central New York and western New England, southward to central Florida; westward to Minnesota, Iowa, eastern Kansas, Missouri, southeastern Oklahoma, and southwestern Arkansas, northern Alabama, western Louisiana, and eastern Texas.

Oven-dry weight per cubic foot, green volume.—30 pounds.

Fiber length.-----

By Sulphite Process

Behavior probably similar to that of red maple.

¹¹ About 15 to 20 per cent when cooked by sulphate process to yields stated.

By Soda Process

Reduces readily.

Unbleached pulp: Rather difficult to bleach.

Yields: 35 to 40 per cent.

Bleach required: 25 to 30 per cent.¹²

By Mechanical Process

Behavior probably similar to that of black gum.

RED MAPLE (*Acer rubrum*)

Other names in use.—Swamp maple, soft maple, and water maple. The trade name of the lumber, mixed with that of silver maple, is soft maple.

Range.—From Newfoundland to southern Florida and westward to western Wisconsin, northwestern Minnesota, southeastern Iowa, eastern Oklahoma, southwestern Oklahoma, southwestern Arkansas, and eastern Texas.

Oven-dry weight per cubic foot, green volume.—30 pounds.

Fiber length.—0.8 mm.

By Sulphite Process

Reduces very easily.

Unbleached pulp: Of rather poor color; usually contains small black specks, which disappear upon bleaching; easily bleached.

Yields: 45 to 50 per cent.

Bleach required: 5 to 15 per cent.

By Soda Process

Reduces vary easily.

Unbleached pulp: Fairly easy to bleach.

Yields: 40 to 45 per cent.

Bleach required: 15 to 20 per cent.

By Mechanical Process

Behavior probably similar to that of black gum.

SUGAR MAPLE (*Acer saccharum*)

Other names in use.—Hard maple, sugar-tree, and rock maple. The lumber is called hard maple and white maple by the trade.

Range.—From southern Newfoundland and Nova Scotia (along the St. Lawrence and Saguenay Rivers, Lake St. John, and the northern borders of the Great Lakes) to Lake of the Woods, Ontario, Minnesota, northeastern South Dakota, Iowa, eastern Kansas, central and southeastern Oklahoma, southwestern Arkansas, and eastern Louisiana; south (through the Northern States and on the Allegheny Mountains) to northern Georgia; west to eastern Nebraska, eastern Kansas, and eastern Texas.

Oven-dry weight per cubic foot, green volume.—35 pounds.

Fiber length.—-----

By Sulphite Process

Reduces very easily.

Unbleached pulp: Of excellent color; bleaches easily.

Yields: 45 to 50 per cent.

Bleach required: 10 to 20 per cent.

By Soda Process

Reduces with some difficulty.

Unbleached pulp: Rather difficult to bleach.

Yields: 40 to 45 per cent.

Bleach required: 25 to 30 per cent.¹³

By Mechanical Process

Behavior probably similar to that of black gum.

¹² About 15 to 20 per cent when cooked by sulphate process to yields stated.

¹³ About 20 to 27 per cent when cooked by sulphate process to yields stated.

PAPER BIRCH (*Betula papyrifera*)

Other names in use.—Canoe birch and white birch.

Range.—From Labrador to Hudson Bay (southern shores); southward to New York (Long Island) and northern Pennsylvania, central Michigan, northern Wisconsin, North Dakota, South Dakota (Black Hills), eastern Nebraska, and Wyoming. The best stands occur in the central portion of Maine, in a strip extending from the coast to the White Mountains of New Hampshire.

Oven-dry weight per cubic foot, green volume.—34 pounds.

Fiber length.—1.2 mm.

By Sulphite Process

Reduces easily.

Unbleached pulp: Of poor color; fairly easy to bleach.

Yields: 45 to 50 per cent.

Bleached required: 10 to 20 per cent.

By Soda Process

Reduces with some difficulty.

Unbleached pulp: Fairly easy to bleach.

Yields: 35 to 40 per cent.

Bleached required: 15 to 20 per cent.

By Mechanical Process

Characteristics similar to those of aspen except that the pulp, though light colored, has a pinkish tinge.

YELLOW BIRCH (*Betula lutea*)

Other names in use.—Gray birch, swamp birch, and silver birch. The lumber is sold as birch.

Range.—From Newfoundland and along the northern shores of St. Lawrence Gulf to Abitibi Lake and Rainy River; southward through northern Minnesota to central Iowa, and through the Northern States to eastern Tennessee, western North Carolina, northern Georgia, and Delaware. Wisconsin, Michigan, and New York have the largest stands.

Oven-dry weight per cubic foot, green volume.—34 pounds.

Fiber length.—1.5 mm.

By Sulphite Process

Reduces readily.

Unbleached pulp: Of good color; fairly easily bleached.

Yields: 45 to 50 per cent.

Bleached required: 15 to 20 per cent

By Soda Process

Reduces with some difficulty.

Unbleached pulp: Fairly easy to bleach.

Yields: 40 to 45 per cent.

Bleach required: 15 to 20 per cent.

By Mechanical Process

Behavior probably similar to that of paper birch.

BEECH (*Fagus grandifolia*, formerly, *F. atropunicea*)

Other names in use.—Red beech and white beech.

Range.—New Brunswick to Lake Huron (northern shores) and Minnesota; south to western Florida and west to Missouri and Texas (Trinity River).

Oven-dry weight per cubic foot, green volume.—36 pounds.

Fiber length.—1.1 mm.

By Sulphite Process

Not determined.

By Soda Process

Reduces with slightly more difficulty than aspen.
Unbleached pulp: Easy to bleach.
Yields: 45 to 50 per cent.
Bleached required: 10 to 15 per cent.

By Mechanical Process

Not determined.

BLACK GUM (*Nyssa sylvatica*)

Other names in use.—Tupelo and pepperidge.

Range.—From Maine (Kennebec River) to northern Florida; west to southern Ontario, southern Michigan, southeastern Missouri, Oklahoma, southwestern Arkansas, and eastern Texas.

Oven-dry weight per cubic foot, green volume.—30 pounds.

Fiber length.—1.7 mm.

By Sulphite Process

Reduces readily.
Unbleached pulp: Fairly easy to bleach.
Yields: 45 to 50 per cent.
Bleach required: 15 to 20 per cent.

By Soda Process

Reduces readily.
Unbleached pulp: Slightly stronger than aspen pulp; rather difficult to bleach.
Yields: 35 to 40 per cent.
Bleach required: 20 to 30 per cent.¹⁴

By Mechanical Process

A pulp of standard strength, very light colored and fine fibered, is produced with a consumption of approximately three times as much power as is required for spruce.

TUPELO GUM (*Nyssa aquatica*)

Other names in use.—Sour gum, bay poplar, cotton gum, large tupelo, swamp poplar, and hickory poplar. The lumber usually goes under the names tupelo and sap gum in the market.

Range.—Atlantic coast region from southern Virginia to northern Florida, and through the Gulf States to central Texas; northward through Arkansas, west Tennessee, and Kentucky, southern and southeastern Missouri to southern Illinois.

Oven-dry weight per cubic foot, green volume.—29 pounds.

Fiber length.—1.6 mm.

By Sulphite Process

Reduces readily.
Unbleached pulp: Of fair color; fairly easily bleached.
Yields: 45 to 50 per cent.
Bleach required: 15 to 25 per cent.

By Soda Process

Reduces readily.
Unbleached pulp: Slightly stronger than aspen pulp; rather difficult to bleach.
Yields: 35 to 40 per cent.
Bleach required: 25 to 30 per cent.¹⁵

By Mechanical Process

Behavior probably similar to that of black gum.

¹⁴About 15 to 25 per cent when cooked by sulphate process to yields stated.

¹⁵About 20 to 27 per cent when cooked by sulphate process to yields stated.

RED GUM (*Liquidambar styraciflua*)

Other names in use.—Gum, sweet gum, liquidambar, and star-leaved gum. In the lumber markets red gum is the name applied to the heartwood and sap gum to the sapwood of the tree. In foreign markets the heartwood is called satin walnut and the sapwood, hazel pine.

Range.—From southwestern Connecticut to southeastern Missouri, Arkansas and Oklahoma, south to central Florida and eastern Texas. The commercial range is largely confined to the moist lands of the lower Ohio and Mississippi basins and the lowlands of the southeastern coast.

Oven-dry weight per cubic foot, green volume.—27 pounds.

Fiber length.—1.6 mm.

By Sulphite Process

Reduces readily.

Unbleached pulp: Dark colored and rather difficult to bleach, differing in this respect from pulps from the true gums (*Nyssa*).

Yields: 45 to 50 per cent.

Bleach required: 35 to 40 per cent.

Uses to which pulp is suited: Limited chiefly by resistance to bleach.

By Soda Process

Reduces fairly readily.

Unbleached pulp: Rather difficult to bleach.

Yields: 35 to 40 per cent.

Bleach required: 15 to 20 per cent.

By Mechanical Process

Behavior probably similar to that of black gum.

CUCUMBER MAGNOLIA (*Magnolia acuminata*)

Other names in use.—Cucumber tree, cucumber, and mountain magnolia. The lumber is usually sold as yellow poplar.

Range.—From western New York through southern Ontario and south to southern Illinois and Indiana, and south in the Appalachian Mountains to southern Georgia, southern Alabama, and northeastern Mississippi, central Kentucky and Tennessee, northeastern, southern, and southwestern Arkansas, and eastern Oklahoma, and southwestern Missouri.

Oven-dry weight per cubic foot, green volume.—27 pounds.

Fiber length.—1.3 mm.

By Sulphite Process

Reduces readily.

Unbleached pulp: Dark colored, rather difficult to bleach.

Yields: 45 to 50 per cent.

Bleach required: 25 to 30 per cent.

Uses to which pulp is suited: Limited chiefly by resistance to bleach.

By Soda Process

Reduces easily.

Unbleached pulp: Rather difficult to bleach.

Yields: 45 to 50 per cent.

Bleach required: 20 to 30 per cent.

By Mechanical Process

Behavior probably similar to that of black gum.

SWEET BAY (*Magnolia virginiana australis*, formerly included as a form of *M. glauca*)

Other names in use.—White bay, swamp laurel, and swamp magnolia.

Range.—From southeastern North Carolina (vicinity of Wilmington) and southward in the coast region of South Carolina and Georgia (to Randolph and Carroll Counties), throughout Florida, and westward in the Gulf States to eastern

Texas (Nueces River, San Augustine County); in Alabama, extending to Macon and Dallas Counties, and also to Sand and Lookout Mountains, in Mississippi, to the northeast corner of the State, and in western Louisiana, to Winn and Natchitoches Parishes.

Oven-dry weight per cubic foot, green volume.—29 pounds.

Fiber length.—1.3 mm.

By Sulphite Process

Reduces readily.

Unbleached pulp: Of poor color; easily bleached.

Yields: 40 to 45 per cent.

Bleach required: 10 to 15 per cent.

By Soda Process

Reduces readily.

Unbleached pulp: Rather difficult to bleach.

Yields: 35 to 40 per cent.

Bleach required: 25 to 30 per cent.¹⁶

By Mechanical Process

Behavior probably similar to that of black gum.

SYCAMORE (*Platanus occidentalis*)

Other names in use.—Button-wood, buttonball-tree, and plane-tree.

Range.—Southwestern Maine to northern Vermont, southern Ontario and Michigan, central and southern Iowa, southeastern Nebraska, eastern Kansas, Oklahoma, and southwestern Arkansas, south to western Florida, central Alabama, and Mississippi, to western Texas.

Oven-dry weight per cubic foot, green volume.—29 pounds.

Fiber length.—1.7 mm.

By Sulphite Process

Reduces readily.

Unbleached pulp: Easily to bleach.

Yields: 45 to 50 per cent.

Bleach required: 10 to 15 per cent.

By Soda Process

Reduces readily.¹⁷

Unbleached pulp: Fairly easy to bleach.

Yields: 45 to 50 per cent.

Bleach required: 15 to 20 per cent.

By Mechanical Process

Not determined.

BUTTERNUT (*Juglans cinerea*)

Other names in use.—White walnut and oil nut.

Range.—Southern New Brunswick to Delaware and in the Appalachian Mountains to Georgia and Alabama, westward through Ontario to eastern South Dakota, eastern Iowa, southeastern Nebraska, central Kansas, southern Missouri, and northern Arkansas.

Oven-dry weight per cubic foot, green volume.—22 pounds.

Fiber length.—1.2 mm.

By Sulphite Process

Reduces readily.

Unbleached pulp: Of poor color; fairly easily bleached.

Yields: 45 to 50 per cent.

Bleach required: 15 to 20 per cent.

By Soda Process

Reduces readily.

Unbleached pulp: Very difficult to bleach.

Yields: 45 to 50 per cent.

¹⁶ 20 to 25 per cent when cooked by sulphate process to yields stated.

¹⁷ The wood is difficult to chip if it is allowed to dry out, presumably on account of the numerous and broad medullary rays.

By Mechanical Process

Not determined.

OHIO BUCKEYE (*Aesculus glabra*)

Other names in use.—Buckeye, American horse chestnut, and stinking buckeye.

Range.—From Pennsylvania (western slopes of the Allegheny Mountains) to northern Alabama, and west to southern Iowa, northeastern Kansas, Missouri, and southeastern Nebraska.

Oven-dry weight per cubic foot, green volume.—21 pounds.

Fiber length.—-----

By Sulphite Process

Reduces readily.

Unbleached pulp: Silver-gray in color; rather difficult to bleach.

Yields: 45 to 50 per cent.

Bleach required: 20 to 25 per cent.

By Soda Process

Reduces fairly readily.

Unbleached pulp: Rather difficult to bleach.

Yields: 40 to 45 per cent.

Bleach required 25 to 30 per cent.

By Mechanical Process

Not determined.

MANGROVE (*Rhizophora mangle*)

Other names in use.—This species is known only as mangrove.

Range.—Southern coast of Florida.

Oven-dry weight per cubic foot, green volume.—56 pounds.

Fiber length.—-----

By Sulphite Process

Not determined.

By Soda Process

Reduces readily.

Unbleached pulp: Short fibered, rather difficult to bleach.

Yields: 40 to 45 per cent.

Bleach required: 25 to 30 per cent.

On account of its exceptionally large yield on the volume basis as a result of its high density, this wood is worthy of consideration as a pulp material, provided means can be devised for harvesting at reasonable cost.

By Mechanical Process

Not determined.

6. HARDWOODS—RING-POROUS

Possible uses: Reference is directed to page 20 for a discussion of the uses of hardwood pulps as a group. Individual species differ as to the ease or difficulty with which pulps of satisfactory quality can be produced rather than as to specific uses for which they may be suited. Therefore no discussion of specific uses of pulps from the individual species will be attempted in the summaries.

Sulphate process: Practically all American hardwoods can be pulped by the sulphate process as readily as by the soda process. The sulphate pulps usually bleach with less bleaching powder than soda pulps; otherwise the two classes show practically no difference in quality. The soda process, however, since it was established earlier than the sulphate and operates with greater freedom from offensive odors, has remained almost without challenge for the pulping of hardwoods. Therefore the sulphate process will be referred to only incidentally in this section.

COMMON CATALPA (*Catalpa bignonioides*, formerly *C. catalpa*)

Other names in use.—Indian bean, bean-tree, common catalpa, catawba, and cigar-tree.

Range.—Believed to be indigenous only in southwestern Georgia, western Florida, central Alabama, Mississippi, and southwestern Missouri. It is widely

cultivated for ornament, however, and is naturalized elsewhere in the eastern United States as far north as southern New York, and also in Europe.

Oven-dry weight per cubic foot, green volume.—31 pounds.

Fiber length.—-----

By Sulphite Process

Reduces fairly readily.

Unbleached pulp: Decidedly pinkish in color, frequently specky; very difficult to bleach.

Yields: 45 to 50 per cent.

Bleach required: 35 to 40 per cent.

By Soda Process

Reduces readily.

Unbleached pulp: Fairly easy to bleach.

Yields: 40 to 45 per cent.

Bleach required: 15 to 20 per cent.

By Mechanical Process

Not determined.

CHESTNUT (*Castanea dentata*)

Other names in use.—Chestnut is one of the few trees of commercial importance that has but one name.

Range.—The entire stand of chestnut in the United States is being rapidly depleted by a fungus disease known as the "chestnut blight." Before it was attacked by the blight, chestnut grew in commercial quantities from New Hampshire and Vermont southward and westward in Connecticut, Massachusetts, New York, Pennsylvania, and along the Appalachian Mountains to northern Georgia. The commercial supply has been greatly diminished by the blight in the northern part of this region, and the best remaining stands are located in the southern Appalachians.

Oven-dry weight per cubic foot, green volume.—25 pounds.

Fiber length.—1 mm.

By Sulphite Process

Reduces fairly readily.

Unbleached pulp: Olive-brown in color; very difficult to bleach.

Yields: 40 to 45 per cent.

Bleach required: 35 to 40 per cent.

By Soda Process

Does not reduce satisfactorily. When extracted, however, for the tannin content, chestnut chips reduce readily. The following statements apply to pulp made from extracted chips:

Unbleached pulp: Bleaches easily.

Yields: 35 to 40 per cent.

Bleach required: 10 to 15 per cent.

By Mechanical Process

Not determined.

HACKBERRY (*Celtis occidentalis*)

Other names in use.—Sugarberry and nettle-tree.

Range.—From New England to Virginia and westward to eastern North Dakota, Iowa, southwestern Missouri, and western Kansas.

Oven-dry weight per cubic foot, green volume.—30 pounds.

Fiber length.—1.1 mm.

By Sulphite Process

Reduced readily.

Unbleached pulp: Exceptionally light colored; easily bleached.

The color of the bleached pulp is better than that obtained with any other wood pulp, comparing favorably with that of the finest bleached cotton.

Yield: 40 to 45 per cent.

Bleached required: 10 to 15 per cent.

By Soda Process

Reduces readily.

Unbleached pulp: Rather difficult to bleach; differs from soda pulps of most other species on account of being noticeably less opaque.

Yields: 35 to 40 per cent.

Bleached required: 20 to 30 per cent.

By Mechanical Process

Not determined.

SASSAFRAS (*Sassafras variifolium*, formerly *S. sassafras*)

Other names in use.—Sassafras is the universal name for this species.

Range.—From southern Maine and eastern Massachusetts through southern Vermont, southern Ontario, and central Michigan, southeastern Iowa to eastern Kansas, Arkansas, and Oklahoma; south to central Florida, and eastern Texas.

Oven-dry weight per cubic foot, green volume.—26 pounds.

Fiber length.—0.9 mm.

By Sulphite Process

Not successfully reduced.

By Soda Process

Reduces readily.

Unbleached pulp: Very difficult to bleach except where yields are too low for commercial consideration.

Yields: 30 to 35 per cent.

Bleach required: 30 to 35 per cent.

By Mechanical Process

Not determined.

ROCK ELM (*Ulmus racemosa*)

Other names in use.—Cork elm and hickory elm. Rock elm is the usual name applied to the lumber.

Range.—From Quebec (eastern townships) through Ontario, and south through northwestern New Hampshire to southern Vermont, and to northern New Jersey; westward through northern New York, southern Michigan, and central Wisconsin; southwestern Minnesota to northeastern Nebraska, western Missouri, eastern Kansas, and middle Tennessee.

Oven-dry weight per cubic foot, green volume.—36 pounds.

Fiber length.—1.3 mm.

By Sulphite Process

Reduces readily.

Unbleached pulp: Of poor color; easily bleached.

Yields: 45 to 50 per cent.

Bleach required: 10 to 15 per cent.

By Soda Process

Reduces readily.

Unbleached pulp: Fairly easy to bleach.

Yields: 45 to 50 per cent.

Bleach required: 20 to 25 per cent.

By Mechanical Process

Not determined.

SLIPPERY ELM (*Ulmus fuiva*, FORMERLY *U. pubescens*)

Other names in use.—This species is also commonly known as red elm and moose elm. The lumber is often sold as "gray elm."

Range.—From the lower St. Lawrence River through Ontario to South Dakota and eastern Nebraska, southeastern Kansas, southwestern Arkansas, and Oklahoma; south to western Florida, central Alabama, and Mississippi, western Louisiana, and central Texas.

Oven-dry weight per cubic foot, green volume.—30 pounds.

Fiber length.—1.7 mm.

By Sulphite Process

Reduces very imperfectly.

Unbleached pulp: Specky and dark.

Yields: 45 to 50 per cent.

Uses to which pulp is suited: Limited chiefly by imperfect reduction.

By Soda Process

Reduces readily.

Unbleached pulp: Difficult to bleach.

Yields: 35 to 40 per cent.

Bleach required: 30 to 40 per cent.¹⁸

By Mechanical Process

Not determined.

AMERICAN ELM (*Ulmus americana*)

Other names in use.—White elm, water elm, and elm. The lumber is known variously as soft elm, gray elm, and hard gray elm.

Range.—From southern Newfoundland to Lake Superior and to the eastern base of the Rocky Mountains, south to southern Florida, west to North Dakota, South Dakota, western Nebraska, central Kansas, Oklahoma, southwestern Arkansas, and west central Texas.

Oven-dry weight per cubic foot, green volume.—27 pounds.

Fiber length.—1.6 mm.

By Sulphite Process

Behavior probably similar to that of rock elm.

By Soda Process

Readily reduced.

Unbleached pulp: Fairly easy to bleach.

Yields: 40 to 45 per cent.

Bleach required: 25 to 30 per cent.¹⁹

By Mechanical Process

Not determined.

WHITE ASH (*Fraxinus americana*)

Other names in use.—Lumber of the several ashes is usually sold as "ash," and the term "white ash" is generally used to indicate heavy, strong material of high quality from which the lighter wood is excluded. Pumpkin ash is a term frequently employed to designate soft and brittle ash wood.

Range.—White ash is found over nearly all the eastern half of the United States. It occurs from Nova Scotia and New Brunswick to Florida and westward through southern Quebec and Ontario to eastern Minnesota, eastern Nebraska and Kansas, Oklahoma, southwestern Arkansas, and eastern Texas.

Oven-dry weight per cubic foot, green volume.—34 pounds.

Fiber length.—1.2 mm.

By Sulphite Process

Reduces fairly readily.

Unbleached pulp: Of poor color, specky; rather difficult to bleach.

Yields: 45 to 50 per cent.

Bleach required: 20 to 30 per cent.

Uses to which pulp is suited: Few.

By Soda Process

Reduces readily.

Unbleached pulp: Rather difficult to bleach.

Yields: 40 to 45 per cent.

Bleach required: 25 to 30 per cent.

Uses to which pulp is suited: Few.

By Mechanical Process

Not determined.

¹⁸ From 15 to 20 per cent when cooked by sulphate process to yields stated.

¹⁹ About 18 to 24 per cent when cooked by sulphate process to yields stated.

RED OAK (*Quercus borealis maxima*, FORMERLY *Q. rubra*)

Other names in use.—Black oak, spotted oak, mountain oak, and Spanish oak. The term "red oak" is used commercially to indicate the wood of a number of species included in the red-oak group, which is one of the two groups (namely "red" and "white") into which the oaks are divided commercially in the trade.

Range.—The northern range is not fully determined. Red oak occurs from western New York and Pennsylvania westward through Ohio and southern Michigan and southward to Georgia, Tennessee, Alabama, and Mississippi to Arkansas and Oklahoma; westward to eastern Nebraska and central Kansas.

Oven-dry weight per cubic foot, green volume.—35 pounds.

Fiber length.—1.5 mm.

By Sulphite Process

Reduces readily.

Unbleached pulp: Of fair color, but specky; rather difficult to bleach.

Yields: 45 to 50 per cent.

Bleach required: 20 to 25 per cent.

Uses to which pulp is suited: Limited chiefly by speckiness.

By Sulphate Process

Reduces readily.

Unbleached pulp: Rather difficult to bleach.

Yields: 35 to 40 per cent.

Bleach required: 15 to 25 per cent.

Uses to which pulp is suited: When undercooked, high yields are obtained of a pulp suitable for the manufacture of wrapping paper of fair strength; otherwise possible uses are few.

By Mechanical Process

Not determined.

WHITE OAK (*Quercus alba*)

Other names in use.—"West Virginia soft white oak," stave oak, and "forked-leaf white oak" are trade names. Lumber of several other species of the white oak group is classed as "white oak".

Range.—From southern Maine to southwestern Quebec and through southern Ontario, Lower Peninsula of Michigan, and southern Minnesota, eastern Iowa, southeastern Nebraska, and eastern Kansas, Arkansas, and Oklahoma; south to western Florida and eastern Texas.

Oven-dry weight per cubic foot, green volume.—37 pounds.

Fiber length.—1.5 mm.

By Sulphite Process

Reduces with some difficulty.

Unbleached pulp: Specky; difficult to bleach.

Yields: 45 to 50 per cent.

Bleach required: 30 to 35 per cent.

By Soda Process

Reduces readily.

Unbleached pulp: Very difficult to bleach.

Yields: 35 to 40 per cent.

Bleach required: 35 to 40 per cent.²⁰

By Mechanical Process

Not determined.

MOCKERNUT HICKORY (*Hicoria alba*)

Other names in use.—Mockernut hickory, mockernut, and white heart hickory. The lumber is generally sold as hickory, a name under which several hickories are included.

Range.—Southwestern Ontario to Florida and west to southeastern Iowa, Missouri, eastern Oklahoma, and southwestern Arkansas, and in the Gulf States to eastern Texas.

Oven-dry weight per cubic foot, green volume.—40 pounds.

Fiber length.—1.4 mm.

²⁰ About 22 to 25 per cent when cooked by sulphate process to yields stated.

By Sulphite Process

Reduces readily.

Unbleached pulp: Specky; rather difficult to bleach.

Yields: 40 to 45 per cent.

Bleach required: 15 to 20 per cent.

By Soda Process

Reduces readily.

Unbleached pulp: Very difficult to bleach.

Yields: 30 to 35 per cent.

Bleach required: More than 35 per cent.²¹

By Mechanical Process

Not determined.

BLACK LOCUST (*Robinia pseudoacacia*)

Other names in use.—Locust and yellow locust.

Range.—From Pennsylvania to northern Georgia, also southern Illinois and southwestern Indiana. Widely naturalized through cultivation and other agencies throughout the United States east of the Rocky Mountains.

Oven-dry weight per cubic foot, green volume.—41 pounds.

Fiber length.—-----

By Sulphite Process

Reduces with difficulty and very unevenly.

Unbleached pulp: Not satisfactory.

By Soda Process

Reduces fairly readily.

Unbleached pulp: Does not bleach satisfactorily.

Yields: 40 to 45 per cent.

By Mechanical Process

Not determined.

AILANTHUS (*Ailanthus altissima*, FORMERLY *A. glandulosa*)

Other names in use.—Tree of Heaven and Chinese sumac.

Range.—Native of China; but has been widely naturalized in the eastern United States.

Oven-dry weight per cubic foot, green volume.—24 pounds.

Fiber length.—1.2 mm.

By Sulphite Process

Not determined.

By Soda Process

Reduces readily.

Unbleached pulp: Very easy to bleach.

Yields: 45 to 50 per cent.

Bleach required: 5 to 10 per cent.

By Mechanical Process

Not determined.

7. MISCELLANEOUS SPECIES

SOAPWEED (*Yucca elata*, formerly *Y. radiosa*)

Other names in use.—Spanish bayonet and Spanish dagger.

Range.—Southwestern Texas to southern Arizona; northern Mexico.

Oven-dry weight per cubic foot, green volume.—18 pounds.

Fiber length.—-----

Sulphite Pulp

Not determined.

Soda Pulp

Soapweed is readily reduced by the soda process, yielding a pulp containing 20 to 30 per cent of rather short fibers. The remainder is pithy material, the

²¹ Bleach requirement greatly reduced when cooked by sulphate process.

cells of which are very little longer than their diameter. A few special uses might be developed for this material, but it could hardly be used for standard pulp products on account of the probable cost of collection, nonuniformity of the pulp obtained, low yields, and the difficulty in completely removing soil and other foreign matter from the material before cooking.

Mechanical Pulp

Not determined.

CABBAGE PALMETTO (*Sabal palmetto*)

Other names in use.—Palmetto and cabbage tree.

Range.—Coast region from North Carolina to southern Florida, and on the Gulf coast to western Florida.

Oven-dry weight per cubic foot, green volume.—23 pounds.

Fiber length.—-----

Sulphite Pulp

Cabbage palmetto under the sulphite process yields 35 to 40 per cent of dark, raw, and brash pulp not suited for any of the common uses.

Sulphate Pulp

Cabbage palmetto can be reduced by the sulphate process under low steam pressure to satisfactory pulp fairly easy to bleach. The pulp is stronger than aspen soda pulp, and may be used in the manufacture of book, magazine, and other similar papers, preferably in combination with 20 to 40 per cent of bleached pulp from coniferous woods. The pulp consists of a mixture of fairly long fibers and pithy material. The proportion of pithy material, however, does not seriously affect the character of the sheet except in so far as it makes it weaker than would be the case with the long-fibered portion alone. Yields of 40 to 45 per cent are obtained, requiring 25 to 30 per cent of standard bleaching powder.

Soda Pulp

Cabbage palmetto when cooked by the soda process yields 35 per cent of coarse, tender fiber difficult to bleach and not suited for any of the common uses.

Mechanical Pulp

Not determined.

CANE (*Arundinaria macrosperma*)

Other names in use.—Large cane and giant cane.

Range.—River bottoms from Virginia to Florida, westward to Louisiana and along the Mississippi and its tributaries as far north as Kentucky, Tennessee, and Missouri.

Oven-dry weight per cubic foot, green volume (in piles).—10 pounds.²²

Fiber length.—-----

Sulphite Pulp

Not determined.

Soda Pulp

Cane reduces readily by the soda process to an easily bleached pulp having greater average fiber length than aspen soda pulp and capable of use in the manufacture of book, magazine, and similar papers. It could probably be used without admixture of longer-fibered pulps from coniferous woods. The fiber is soft, opaque, and contains much less pith than is usual for this sort of material. Yields of 33 to 42 per cent are obtained, requiring 15 to 18 per cent of standard bleaching powder.

Mechanical Pulp

Not determined.

²² When chopped for the digester, the material occupies 1 cubic foot for each 14 pounds of oven-dry material, in comparison with 10 pounds to the cubic foot of space occupied by spruce chips.)

8. CHILEAN WOODS²³

OLIVILLO

Description.—The bark is light ash-gray, about one-half inch thick, compact, comparatively smooth, and is not broken into fissures nor can it be readily separated into scales. The wood does not resemble any commercial native wood. It has a very open structure and contains one-quarter by volume of wood fibers having walls of moderate thickness, the rest being made up of parenchyma or vascular tissue.

Oven-dry weight per cubic foot, green volume.—-----

Fiber lengths.—Average, 2.15 mm.; maximum, 2.62 mm.; minimum, 1.34 mm.

Soda Pulp

Olivillo yields a pulp with a longer fiber than has been obtained from any North American hardwoods, which would render it suitable for use unbleached in the manufacture of wrapping paper of considerable strength. Although it is rather difficult to bleach, with bleaching in two stages economical means of operation might possibly be evolved. Yields of 35 to 40 per cent are obtained, requiring 30 to 40 per cent of standard bleaching powder.

LAUREL (*Laurelia aromatica*)

Range.—Laurel grows from 34° south latitude to Llanquihue, Chile.

Description.—The bark is dark reddish brown, about one-half inch thick, is not broken into fissures but can be readily separated into scales. The wood resembles that of silver maple (*Acer saccharinum*). Fiber walls are moderately thick.

Oven-dry weight per cubic foot, green volume.—-----

Fiber lengths.—Average, 0.86 mm.; maximum, 1.02 mm.; minimum, 0.7 mm.

Soda Pulp

The action of the caustic soda in cooking is slower than with most species, and the same is true with the solutions in bleaching. The pulp is similar to aspen soda pulp. Yields of 40 per cent are obtained, requiring 30 to 35 per cent of standard bleaching powder.

COIGUE (*Nothofagus dombeyi*)

Range.—Grows abundantly throughout Chile.

Description.—The bark is grayish, one-half inch thick, and separated into low flat ridges. The inner bark is very fibrous. The wood strongly resembles red gum (*Liquidambar styraciflua*), with about the same proportion of vascular and woody tissue and fairly thick-walled fibers, although the pores are slightly larger.

Oven-dry weight per cubic foot, green volume.—-----

Fiber lengths.—Average 0.85 mm.; maximum, 1.02 mm.; minimum, 0.7 mm.

Soda Pulp

Coigue is readily reduced by the soda process to fairly easily bleached pulp similar to aspen soda pulp. Yields of 40 to 45 per cent are obtained, requiring 15 to 20 per cent of standard bleaching powder.

LINGUE (*Persea lingue*)

Range.—From Aconcagua to Llanquihue, Chile.

Description.—The bark is deep reddish brown about one-half inch thick and strongly resembles that of hemlock. It is separated by narrow fissures into broad flat plates. The wood strongly resembles butternut (*Juglans cinerea*), and has large pores. The fibers are moderately thin-walled with comparatively large lumen.

Oven-dry weight per cubic foot, green volume.—-----

Fiber lengths.—Average, 1.11 mm.; maximum, 1.6 mm.; minimum, 0.61 mm.

Soda Pulp

Yields of 40 to 45 per cent are obtained, requiring 20 to 30 per cent of standard bleaching powder.

²³ These woods were submitted by Senor Alejandro Rosselot, member of Congress, Santiago, Chile.

ROBLE PELLIN (*Nothofagus obliqua*)

Range.—From 33° south latitude to Llanquihue, Chile.

Description.—The bark is reddish brown with light-gray particles. It is one-half inch thick, not ridged, and readily separated into thin, broad, flat scales. The wood closely resembles coigue.

Oven-dry weight per cubic foot, green volume.—-----

Fiber lengths.—Average, 1.45 mm.; maximum, 1.76 mm.; minimum, 1.12 mm.

Soda Pulp

Roble pellin is readily reduced by the soda process, but the pulp is very difficult to bleach. Yields of 30 to 35 per cent are obtained, requiring 35 to 40 per cent of standard bleaching powder.

There is little likelihood of this species being considered for pulp, on account of its great durability and consequently higher value for railroad ties and structural timber.

QUILLAI (CHILEAN CANE) (*Quillaja saponaria*)

Description.—Resembles cane, except that it is solid and much stronger.

Oven-dry weight per cubic foot, green volume.—-----

Fiber lengths.—Average, 2.2 mm.; maximum, 2.66 mm.; minimum, 1.34 mm.

Soda Pulp

Quillai reduces readily by the soda process, yielding 40 to 45 per cent of pulp of very good fiber length and capable of use in the manufacture of papers of moderate strength.

On account of the light color of the pulp it might be considered for use unbleached in the manufacture of newsprint.

TABLES OF COOKING AND STRENGTH DATA

Tables 6 to 18 give for most of the woods included the results of a majority of the test cooks made. They cover cooking conditions, yields, and strength of the resulting pulps. For reasons already stated, the data are not in all cases representative of what are, according to the final conclusions, the practical pulping characteristics of the species. They may be considered, however, as illustrative of possible operating conditions, which in some cases are to be avoided rather than imitated.

The column headings in the tables are, in general, self-explanatory. In the tables of sulphite cooks the columns showing the composition of the cooking liquor give the percentage of SO₂ in the liquor as free, combined, and total, with the commonly accepted understanding that the free is the excess over that required to combine with the base and form normal sulphite, even though the latter does not exist as such. "Duration of cook" is the total time of cooking, from turning on steam to blowing. The steam pressures shown refer in all cases to pressures above atmospheric. It is to be noted that these are partial pressures as distinguished from total pressures shown on the gauge. The quantity of bleach required was found by methods already described in "Experimental procedure."

In the strength data the strength factor is obtained by dividing the Mullen test value by the weight per ream of the paper tested. The average stretch and average breaking length are the average of those values in each direction as determined on the Schopper tensile strength tester for paper. The number of double folds was obtained on the standard Schopper folding tester. In the cases of both the folding and the tearing tests due allowance must be made for the weight of the sheet, since the values have not been converted to a standard or unit weight basis for want of any known conversion factor. Strength tests are shown for relatively few of the cooks of hardwoods, since, on account of their short fibers, hardwoods are not often used in papers where strength is of major importance.

Some of the raw cooks listed in the tables were worked into paper by a special beater treatment. This would indicate possibilities of combining chemical with mechanical disintegration of the chips and of producing paper of moderate strength from unbleached pulps at yields between 70 and 80 per cent. Work with caustic soda and caustic soda and sulphur has recently demonstrated this to be possible. Light-colored sulphite pulps with yields of over 70 per cent have been made, but additional work is necessary to perfect the details. The bearing of these developments on the utilization of mill waste or of southern woods for newsprint is apparent. The exceptional strength of pulp so obtained from the hardwoods is also of interest.

TABLE 6.—Cooking and strength data: *The spruces—Sulphite process*

Species	Cooking data															
	Shipment No.	Cook No.	Date	Quantity of wood used		Cooking liquor				Cooking period						
				Moist weight	Oven-dry weight	Composition			Per 100 pounds chips		Time to maximum temperature	Time to maximum pressure	Duration of cook	Maximum temperature	Maximum pressure per square inch	Gas pressure at blow per square inch
Total	Free	Combined	Volume	SO ₂												
				Pounds	Pounds	Per cent	Per cent	Per cent	Gallons	Per cent	Hours	Hours	Hours	° C.	Pounds	Pounds
Black spruce (<i>Picea mariana</i>)	501	555	Apr. 11, 1921	73.4	66.0	4.97	3.76	1.21	86.8	---	8.00	4.75	8.00	133	100	10
		561	Mar. 30, 1921	79.8	69.5	5.28	4.13	1.15	82.7	---	8.00	4.00	8.00	133	100	4
		574	Apr. 25, 1921	70.0	62.5	5.02	3.74	1.28	93.3	---	8.00	4.70	8.00	150	98	5
		504	Dec. 10, 1920	77.9	65.0	5.26	4.08	1.18	---	---	8.00	5.25	8.00	154	97	8
Blue spruce (<i>Picea pungens</i>)	490	339	July 16, 1917	74.6	64.0	5.68	4.44	1.24	---	---	8.75	2.75	8.75	155	98	10
		502	Apr. 23, 1908	13.2	12.7	4.12	3.07	1.05	---	121.0	7.00	---	10.00	---	---	---
		447	Aug. 16, 1920	70.6	61.4	5.45	4.36	1.09	90.2	---	8.00	4.40	8.00	153	100	4
		795	Oct. 13, 1920	70.9	62.5	5.47	4.28	1.19	96.8	---	8.00	4.00	8.00	153	100	8
Norway spruce (<i>Picea abies</i>)	226	477	Apr. 21, 1921	58.3	51.5	5.37	4.12	1.25	112.7	---	8.00	3.50	8.00	153	100	10
		572	Apr. 26, 1921	59.2	51.6	5.72	4.62	1.10	112.5	---	8.00	3.50	8.00	153	100	10
		575	Oct. 12, 1917	73.0	63.6	5.50	4.13	1.37	---	---	8.00	2.75	8.00	152	90	6
		348	Nov. 4, 1917	68.7	59.6	5.49	4.36	1.13	---	---	7.25	3.50	8.00	153	100	6
Sitka spruce (<i>Picea sitchensis</i>)	504	358	Oct. 15, 1919	63.3	59.7	5.38	4.24	1.14	89.5	46.4	8.00	5.50	8.00	153	100	10
		390	Oct. 30, 1919	72.6	63.7	4.26	3.11	1.15	99.5	32.9	9.75	3.50	10.50	153	100	8
		334	Mar. 21, 1917	85.0	74.4	5.70	4.50	1.20	---	---	9.00	3.00	9.00	150	100	12
		336	July 10, 1917	96.1	84.5	5.86	4.56	1.30	---	---	8.25	2.25	8.25	153	100	10
White spruce (<i>Picea glauca</i>)	469	347	Oct. 11, 1917	85.1	75.7	5.80	4.17	1.63	---	---	7.25	3.50	7.50	150	100	10
		347	Oct. 1, 1920	74.8	64.8	4.96	3.95	1.01	190.2	---	3.50	0.00	3.50	161	75	0
		536	Feb. 17, 1921	66.1	55.8	5.42	4.30	1.12	106.0	---	8.00	3.75	8.00	153	100	4
		537	Feb. 18, 1921	72.7	59.2	5.39	4.30	1.09	103.0	---	8.00	4.00	8.00	153	100	4
	636		Mar. 7, 1922	115.6	88.3	5.60	4.46	1.14	70.3	---	15.00	3.50	15.00	137	65	32

Species	Cooking data—Continued					Strength data							Conditions during test			
	Ship-ment No.	Cook No.	Date	Yields based on oven-dry weight of chips charged		Bleach available (35 per cent)	Calen-dered	Weight per ream, 24x36—500	Thick-ness	Mullen test per square inch	Strength factor per pound ream	Aver-age break-ing length	Aver-age double folds	Aver-age Elmen-dorf tearing test	Rela-tive humid-ity	Tem-pera-ture
				Crude pulp	Screen-ings											
				Per cent	Per cent	Pounds	Yes	Pounds	0.001 in.	Pounds	Points	Per cent	Meters	Grams	Per cent	° F.
Black spruce (<i>Picea mariana</i>).	501	555	Apr. 11, 1921	44.5	0.66	8	Yes	44.5	3.0	30.2	0.68	2.76	6,040	1,079	65	79
		561	Mar. 30, 1921	44.0	.45	10	Yes	48.1	3.0	38.2	.80	3.13	6,563	1,048	66	76
		574	Apr. 25, 1921	46.4	.66	20	Yes	57.5	3.9	54.3	.94	3.60	6,966	1,766	65	88
Blue spruce (<i>Picea pungens</i>)	792	504	Dec. 10, 1920	46.3	1.20		Yes	39.5	2.8	38.8	.98	2.54	7,572	634	66	70
Engelmann spruce (<i>Picea engelmannii</i>)	490	339	July 16, 1917	49.7	.23	16	Yes	41.5	3.8	34.1	.82	2.63	5,870	1,990	67	88
Do.	502	4	Apr. 23, 1908	46.2	.50	12	Yes	49.0	3.4	37.3	.76	2.23	7,310	744	65	80
Norway spruce (<i>Picea abies</i>).	795	447	Aug. 16, 1920	48.6	1.63		Yes	52.9	3.4	33.0	.62	1.62	5,228	284	66	84
		477	Oct. 13, 1920	40.1	.69	12	Yes	46.0	3.3	48.5	1.06	2.81	6,791	1,618	65	87
		572	Apr. 21, 1921	51.0	.59	17	Yes	65.1	4.2	67.2	1.03	3.60	8,054	2,400	64	78
Red spruce (<i>Picea rubra</i>)	226	575	Apr. 26, 1921	47.2	.43	20	Yes	51.0	5.0	40.2	.79	3.38	5,285	746	64	73
		348	Oct. 12, 1917	58.9	.14	25	Yes	51.9	4.1	48.3	.93	3.65	6,690	1,336	65	75
		358	Nov. 4, 1917	52.0	.33	27	No	37.7	3.8	22.3	.59	3.70	7,18	718	66	75
Sitka spruce (<i>Picea sitchensis</i>).	504	390	Aug. 15, 1919	51.6		23	No	38.5	2.7	18.8	.49	2.41	5,930	533	65	73
		399	Oct. 30, 1919	51.5	.10	8	Yes	46.0	4.1	46.7	1.02	3.10	7,040	880	65	71
		334	Mar. 21, 1917	48.6	.35	16	Yes	43.5	3.8	32.0	.74	2.90	5,880	785	65	94
White spruce (<i>Picea glauca</i>).		336	July 10, 1917	47.1	.37	14	Yes	45.5	4.2	37.2	.82	3.70	5,790	1,182	64	75
		347	Oct. 11, 1917	47.8		23	Yes	50.9	3.6	37.1	.73	1.87	6,580	646	64	88
		469	Oct. 1, 1920	57.5	.43	N. B.	Yes	53.8	4.0	39.7	.74	1.96	7,068	967	66	74
		536	Feb. 17, 1921	45.8	.40	14	Yes	49.0	4.0	30.6	.62	1.79	5,425	153	64	73
		537	Feb. 18, 1921	45.6	.20	14	Yes	53.8	4.5	37.1	.69	2.80	6,600	4,555	65	71
	636	Mar. 7, 1922	48.4	.13	18	Yes										

¹ Impregnation used.² 2.300 c. c. H₂SO₄, 1.13 sp. gr., added.³ Pulp of excellent strength and quality. Not run into paper.⁴ Ball mill tests gave 1,240 folds.

TABLE 7.—Cooking and strength data: The spruces—Soda or sulphate process

Species	Shipment No.	Cook No.	Date	Quantity of wood used		Cooking data										Black liquor ratio combined to total alkali							
				Moist weight		Over-dry weight		Before penetration				After penetration		Penetration			Cooking liquor						
				Lbs.	Oven-dry weight	Volume		Concentration		Gal-lons	NaOH	Na2S	Grams per liter	Grams per liter	Lbs.		Grams per liter	NaOH	Na2S	Concentration	Per 100 pounds bone-dry chips	NaOH	Volume
						Grams per liter	Gal-lons	Grams per liter	Grams per liter														
Black spruce (<i>Picea mariana</i>)	501	1187	Oct. 11, 1917	61.9	51.9	50.0	56.3	40.0	37.9	15	97	72.4	37.3	8.0	25.7	42.0	60.0						
		194	Oct. 23, 1917	67.2	55.9	50.0	56.3	40.0	37.9	15	97	58.2	29.0	6.4	26.3	60.0							
		238	May 6, 1918	65.3	57.8	50.0	44.2	30.0	36.6	12	100	78.6	12.0	4.8	44.7								
		706	July 19, 1918	65.0	57.8							45.0	25.0	18.8	48.0								
Blue spruce (<i>Picea pungens</i>)	792	707	Nov. 29, 1920	77.2	64.2							100.0	25.0	6.2	30.0								
		715	Dec. 17, 1920	52.2	46.4							75.2	25.0	18.8	48.0								
		130	May 2, 1917	72.3	55.1	50.0	56.0	32.0	38.3	15	105	64.6	21.5	5.0	27.8	83.5							
		132	May 8, 1917	66.0	51.2	50.0	56.0	31.3	39.2	10	105	68.6	23.8	5.0	25.0	61.0							
Engelmann spruce (<i>Picea engelmannii</i>)	490	221	Dec. 11, 1917	69.5	61.7	50.0	90.0			20	97	104.4	20.9	6.2	24.6	65.0							
		273	Sept. 15, 1920	83.6	73.7							79.9	20.0	5.0	30.0	75.0							
		274	Sept. 16, 1920	78.1	66.9							77.0	19.2	4.0	25.0	84.2							
		275	Sept. 17, 1920	71.0	63.2							111.5	16.0	4.0	25.0	84.2							
Red spruce (<i>Picea rubra</i>)	226	68	Aug. 4, 1916	74.0	64.3	49.0	55.3	40.0	35.4	20	110	78.0	44.6	8.6	23.0								
		71	Aug. 9, 1916	74.0	65.3	50.0	57.5	45.0	36.8	15	55	41.9	18.0	10.0	40.0								
		72	Aug. 10, 1916	74.0	65.1	50.0	57.5	45.0	38.3	15	55	89.4	45.2	7.9	21.0								
		217	Oct. 4, 1917	57.3	49.9	50.0	90.0			17	97	101.2	31.1	6.5	25.0	53.0							
Sitka spruce (<i>Picea sitchensis</i>)	504	191	Oct. 18, 1917	66.9	59.5	50.0	49.2	35.0	35.8	10	100	77.4	38.0	16.2	40.0								
		232	Apr. 25, 1918	70.4	61.6							27.0	48.0	9.0	16.0	20.0							
		235		69.5	61.0							36.0	30.0	12.0	10.0	40.0							
		236	May 3, 1918	68.5	59.4							41.9	18.0	14.0	6.0	40.0							
White spruce (<i>Picea glauca</i>)	225	233	Apr. 26, 1918	66.9	60.2							45.1	12.0	15.0	4.0	40.0							
		239	May 7, 1918	67.6	60.0							45.0	12.0	15.0	4.0	40.0							
		237		61.6								48.1	6.0	16.0	2.0	40.0							
		776	June 8, 1921	68.2	60.4							86.9	19.9	21.7	5.0	30.0	81.8						
	225	777	June 9, 1921	69.2	60.6							100.0	25.0	6.7	12.3	81.0							
		2	Jan. 17, 1916	97.2	84.1	43.0	65.2	45.6	34.6	30	100	136.0	64.7	14.0	6.7	23.2	91.0						
		4	Jan. 23, 1916	96.1	83.7	49.2	80.0	24.4	31.2	30	105	99.7	23.4	19.3	8.2	23.5							
		9	July 8, 1916	147.5	73.0	43.5	70.6	44.7	35.1	20	110	71.9	41.9	20.3	27.4	75.9							
		109	Dec. 7, 1916	82.0	71.9	50.0	84.2			25	110	83.0	20.3	31.0	47.3	68.0							
		223	Dec. 17, 1917	100.0	85.0							85.4	22.0	32.6	75.0								

[illegible]

TABLE 8.—Cooking and strength data: The pines—Sulphite process

Cooking data														
Species	Ship-ment No.	Cook No.	Date	Quantity of wood used		Cooking liquor				Cooking period				
				Moist weight	Oven-dry weight	Composition			Per 100 pounds chips		Time to maximum temperature	Duration of cook	Maximum temperature	Maximum pressure at blow per square inch
						Total	Free	Com-bined	Volume	SO ₂				
				Pounds	Pounds	Per cent	Per cent	Per cent	Gallons	Per cent	Hours	° C.	Pounds	
Lumber pine (<i>Pinus flexilis</i>)	465	548	Mar. 10, 1921	86.0	72.3	5.12	3.57	1.55	75.3	Per cent	7.50	158	100	
Pinon (<i>Pinus edulis</i>)	792	506	Dec. 14, 1920	91.6	75.8	5.20	3.84	1.36	78.0	---	8.00	154	100	
Sugar pine (<i>Pinus lambertiana</i>)		357	Nov. 13, 1917	59.6	52.1	5.46	4.22	1.24	---	---	8.00	152	100	
		357	Nov. 27, 1917	60.8	53.4	4.84	3.73	1.11	---	---	7.75	152	100	
Northern white pine (<i>Pinus strobus</i>)	501	368	Dec. 4, 1917	55.7	48.6	5.49	4.28	1.21	---	---	8.00	153	102	
		369	Dec. 7, 1917	68.5	58.6	5.54	4.32	1.22	---	---	8.00	153	100	
Jack pine (<i>Pinus banksiana</i>)	798	434	Mar. 29, 1920	68.8	60.4	5.68	4.32	1.36	100.0	49.4	7.75	160	100	
		437	Apr. 2, 1920	71.2	66.3	5.48	4.38	1.10	94.0	44.6	8.00	153	100	
Loblolly pine (<i>Pinus taeda</i>)	801	554	Mar. 18, 1921	60.0	52.9	5.41	4.40	1.01	122.2	47.5	8.00	153	100	
Lodgepole pine (<i>Pinus contorta</i>)	323	533	Aug. 17, 1921	92.0	65.4	5.43	4.11	1.32	101.0	---	8.25	156	100	
Longleaf pine (<i>Pinus palustris</i>)	259	301	Oct. 18, 1916	84.0	74.8	5.90	4.26	1.64	156.0	---	7.75	154	98	
Monterey pine (<i>Pinus radiata</i>)	811	508	Dec. 16, 1920	114.2	89.0	5.70	3.98	1.72	144.8	---	8.00	158	100	
Norway pine (<i>Pinus resinosa</i>)	501	550	Mar. 14, 1921	86.1	73.6	5.38	3.98	1.44	---	---	2.75	136	120	
		428	Mar. 17, 1921	92.1	68.2	5.43	3.99	1.48	78.0	38.1	8.00	153	100	
Pitch pine (<i>Pinus rigida</i>)	818	433	Mar. 26, 1920	76.8	68.6	5.62	4.38	1.24	78.0	---	8.00	154	100	
		550	Mar. 24, 1920	84.0	74.8	5.30	3.80	1.50	67.4	46.4	4.25	153	100	
Pond pine (<i>Pinus rigida serotina</i>)	821	591	Dec. 19, 1920	109.6	83.5	5.42	4.07	1.31	99.6	---	8.00	160	100	
		593	Mar. 14, 1921	86.1	73.6	5.38	3.76	1.82	84.3	41.7	7.50	153	100	
		433	Mar. 26, 1920	76.8	68.6	5.52	4.30	1.22	87.5	37.9	8.00	155	100	
		591	May 3, 1920	76.8	68.6	4.95	3.81	1.14	88.3	---	1.75	153	100	
		593	June 13, 1921	124.2	94.5	5.12	3.86	1.26	63.2	---	7.25	155	100	
		403	Nov. 6, 1919	109.6	83.5	5.42	3.96	1.26	71.1	---	11.00	148	100	
		20	Nov. 1912	48.0	39.4	3.90	2.98	1.14	---	---	8.00	153	100	
Scotch pine (<i>Pinus sylvestris</i>)	795	456	Sept. 9, 1920	86.1	72.3	5.94	2.90	1.97	167.3	54.6	8.00	148	80	
		558	Mar. 24, 1921	78.0	66.8	5.47	3.97	1.57	89.5	---	2.75	153	100	
Virginia pine (<i>Pinus virginiana</i>)	19-21	3	Jan. 23, 1907	44.4	37.3	4.35	2.84	1.51	80.5	---	8.00	158	100	
		3	Mar. 4, 1907	25.0	22.2	4.35	2.87	1.39	202.0	44.0	5.20	153	90	
Shortleaf pine (<i>Pinus echinata</i>)	342	432	Mar. 25, 1920	80.4	70.7	4.42	4.12	1.28	87.3	40.8	8.50	150	90	
Western yellow pine (<i>Pinus ponderosa</i>)		333	Feb. 12, 1921	57.4	49.0	4.70	3.69	1.01	120.8	---	11.00	153	100	
		336	Mar. 25, 1920	80.4	70.7	4.42	4.12	1.28	87.3	40.8	8.00	153	100	
Pehuén (Monkey-puzzle) (<i>Araucaria araucana</i>)	455	373	Mar. 16, 1917	88.0	60.9	5.61	4.31	1.30	---	---	2.60	161	100	
		373	Mar. 28, 1917	83.0	76.8	5.56	4.26	1.30	---	---	8.00	149	96	
		376	June 3, 1918	102.2	73.8	5.64	4.40	1.24	---	---	3.00	152	100	
			June 7, 1918	113.9	80.9	4.59	3.50	1.09	---	---	2.75	155	100	
						4.59	3.50	1.09	---	---	3.50	152	100	

Cooking data—Continued				Strength data										Conditions during test		
Species	Ship-ment No.	Cook No.	Date	Yields based on oven-dry weight of chips effarged		Bleach required (35 per cent available chlorine) per 100 pounds oven-dry pulp	Calendered	Weight per ream 24 by 36—500	Thick-ness	Mullen test per square inch	Strength factor per pound per ream	Aver- age break- ing length	Aver- age double folds	Aver- age Elmen- dorf tearing test	Relative humid- ity	Tem- perature
				Crude pulp	Screen- ings											
				Per cent	Per cent	Pounds	(1)	Pounds	0.001 in.	Pounds	Points	Per cent	Meters	Grams	Per cent	° F.
Limber pine (<i>Pinus flexilis</i>)	465	548	Mar. 10, 1921	43.1	1.87	24	Yes	42.5	3.1	26.7	.63	1.62	4,144	162	65	70
	792	506	Dec. 14, 1920	50.3	.69	27	Yes	40.5	3.6	31.4	.77	2.40	5,650	758	64	76
		357	Nov. 13, 1917	50.4	.95	31	Yes	41.5	3.7	28.8	.69	2.30	4,925	444	60	69
Sugar pine (<i>Pinus lambertiana</i>)	501	368	Dec. 4, 1917	56.5	1.02	46	Yes	48.1	4.0	32.7	.79	2.10	5,710	456	61	64
		369	Dec. 7, 1917	55.6			Yes	48.1	5.0	30.7	.64	2.12	5,145	433	61	64
		434	Mar. 29, 1920	50.3	6.08	234	Yes	38.0	2.7	18.6	.49	2.14	4,082	167	65	72
Jack pine (<i>Pinus banksiana</i>)	798	437	Apr. 4, 1920	47.1	2.42	830	Yes	38.5	2.7	21.5	.56	1.17	5,403	107	65	75
	500	Nov. 21, 1920	46.9	.40		Yes	39.5	4.1	42.5	.72	2.53	5,472	258	66	71	
	422	Mar. 10, 1920	50.6	1.82	33	Yes	55.2	4.6	28.4	.51	2.40	4,667	453	67	79	
Loblolly pine (<i>Pinustaeda</i>)	801	554	Mar. 18, 1921	43.5	.84	12	Yes	70.8	5.1	30.8	.44	2.09	4,056	252	64	78
	323	343	Aug. 13, 1917	48.6	1.61	24	Yes	45.5	3.7	36.7	.81	4.61	6,815	1,055	68	78
		533	Mar. 17, 1921	44.1	.44	12	Yes	48.1	3.5	35.6	.74	2.34	6,290	939	65	78
Longleaf pine (<i>Pinus palustris</i>)	259	301	Oct. 18, 1916	54.7			(4)	47.0	4.1	22.9	.49	2.42	4,156	262	64	68
	431	508	Mar. 24, 1920	49.9	2.82	29	Yes	45.5	3.5	25.6	.58	1.35	5,000	134	64	72
	811	428	Dec. 16, 1920	53.0	3.58	34	Yes	33.0	2.6	16.8	.51	1.97	5,889	305	67	70
Norway pine (<i>Pinus resinosa</i>)	501	550	Mar. 19, 1920	50.1	3.44	335	Yes	78.4	2.1	35.1	.45	2.18	3,417	202	65	78
	818	433	Mar. 14, 1921	44.9	.92	18	Yes	33.0	2.5	12.2	.37	1.97	4,622	76	65	71
	443	May 3, 1920	49.1	5.42	32	Yes	43.5	3.0	23.9	.55	2.75	4,778	120	64	77	
Pond pine (<i>Pinus rigida serotina</i>)	821	591	June 8, 1920	43.0	4.96	39	Yes	51.0	3.9	23.9	.47	3.18	3,213	38	66	92
	593	Nov. 13, 1921	44.2	3.59	16	Yes	48.0	3.5	20.1	.42	1.93	3,256	38	66	93	
	403	June 6, 1919	17			14	Yes	41.5	2.9	18.4	.44	1.80	4,175	225	64	78
Sand pine (<i>Pinus clausa</i>)	178	20	Nov. 6, 1919	23.1	.40		Yes	38.5	3.2	26.3	.68	1.54	4,716	265	64	83
	795	456	Sept. 9, 1920	49.9	12.20	30	Yes	48.0	3.8	19.2	.40	2.03	3,827	255	64	75
	558	Mar. 21, 1921	36.8		(5)	Yes										
Virginia pine (<i>Pinus virginiana</i>)	19-21	3	Jan. 23, 1907		1.10	120										
	20	3	Mar. 4, 1907			728										
	342	432	Mar. 25, 1920	48.0			Yes	39.5	3.0	17.4	.44	1.84	4,949	145	64	69
Western yellow pine (<i>Pinus ponderosa</i>)	455	528	Feb. 2, 1921	44.0	4.88	627	Yes	60.4	2.4	19.1	.32	.88	2,811	33	62	73
	333	Mar. 16, 1917	58.0		(6)	Yes	56.0	5.4	31.2	.56	2.40	5,620	143	65	79	
	335	Mar. 28, 1917	47.6	.46		Yes	49.0	4.4	22.8	.47	2.60	4,510	47	66	71	
Pehuén (<i>Monkey-puzzle</i>) (<i>Araucaria araucana</i>)	373	June 3, 1918	53.1	.70		Yes	47.0	3.7	21.0	.44	2.55	3,560	66	68	81	
	376	June 7, 1918	51.5	.30		Yes	53.0	4.0	23.3	.44	3.07	3,457	156	63	83	

¹ Pulp extremely raw. Not run into paper.² Unbleached pulp of very good color.³ Unbleached pulp of very good color. Paper exceptionally free from shives.⁴ Pulp badly burned. Not run into paper.⁵ Pulp evidently burned.⁶ Ratio lime to magnesia, 17:10.⁷ Pulp of excellent strength and quality. Not run into paper.

TABLE 9.—Cooking and strength data: The pines—soda or sulphate process

Species	Shipment No.	Cook No.	Date	Cooking data																
				Quantity of wood used		Impregnating liquor				Penetration		Cooking liquor								
				Moist weight	Oven-dry weight	Before penetration		After penetration		Duration	Pressure per square inch	Temperature	Concentration		Per 100 pounds bone-dry chips		Black liquor ratio combined to total alkali			
						Volume	Concentration		Volume				Concentration		NaOH	Na ₂ S		NaOH	Na ₂ S	Volume
							Gal- lons	Grams per liter					Gal- lons	Grams per liter						
Lumber pine (<i>Pinus flexilis</i>)	465	189 193 717 718 726 727 728 199 229 723	Oct. 15, 1917 Oct. 23, 1917 Jan. 4, 1921 Jan. 6, 1921 Jan. 24, 1921 Feb. 3, 1921 Feb. 16, 1921 Apr. 27, 1917 Oct. 30, 1917 Jan. 11, 1918 Jan. 19, 1921	Lbs. 64.2 64.2 80.9 95.4 34.6 34.6 27.1 64.4 68.9 65.0 66.1	Lbs. 57.0 57.0 62.5 75.6 28.8 28.8 26.1 56.4 60.5 58.3 59.6	Gal- lons 50.0 50.0 48.8	Grams per liter 56.4 50.5	Gal- lons 35.5 35.9	Grams per liter 48.8 43.8	Grams per liter 41.0 31.3	Min- utes 15 15	Lbs. 100 100	° C. 62 48	Grams per liter 70.7 65.2	Lbs. 7.7 6.1	Gal- lons 27.0 24.0	Per cent 61.0 58.8			
Pinon (<i>Pinus edulis</i>)	792	726 727 728	Jan. 6, 1921 Jan. 24, 1921 Feb. 16, 1921	Lbs. 44.4 34.6 32.4	Lbs. 38.6 28.8 27.1	Gal- lons 50.0 50.0 50.0	Grams per liter 56.0 46.5 38.0	Gal- lons 35.5 37.6	Grams per liter 48.8 70.7	Grams per liter 35.0 32.8	Min- utes 20 15	Lbs. 105 100	° C. 78 61	Grams per liter 63.0 101.4	Lbs. 11.3 7.6	Gal- lons 20.8 23.8	Per cent 75.4 75.4			
Sugar pine (<i>Pinus lambertiana</i>)	455	139 195 729 730	June 5, 1917 Oct. 24, 1917 Feb. 17, 1921 Feb. 18, 1921	Lbs. 90.4 64.1 64.2 62.0	Lbs. 52.2 56.1 56.2 55.0	Gal- lons 50.0 50.0 50.0 45.0	Grams per liter 56.0 46.5 31.7	Gal- lons 39.8 36.9	Grams per liter 45.8 44.8	Grams per liter 29.7 31.9	Min- utes 10 10	Lbs. 110 102	° C. 44 43	Grams per liter 75.0 100.7	Lbs. 25.0 17.8	Gal- lons 25.0 30.0	Per cent 84.8 86.0			
Northern white pine (<i>Pinus strobus</i>)	501	21 22 24 77 85	Apr. 11, 1916 Apr. 13, 1916 Apr. 17, 1916 Aug. 18, 1916 Sept. 6, 1916	Lbs. 120.0 120.0 73.4 82.0 56.8	Lbs. 71.3 70.1 45.0 66.8 50.1	Gal- lons 50.0 50.0 50.0 50.0	Grams per liter 70.0 82.5 60.0	Gal- lons 36.2 33.8 38.2	Grams per liter 51.9 44.7 48.1	Grams per liter 35.3 46.0 35.0	Min- utes 20 20 15	Lbs. 100 100 100	° C. 85 94 84	Grams per liter 87.3 102.0 85.3	Lbs. 5.3 6.7 5.5	Gal- lons 20.6 29.1 25.4	Per cent 76.2 74.0 74.0			
Jack pine (<i>Pinus banksiana</i>)	431	89 90 92 100 222 247 249 251 836	Sept. 13, 1916 Sept. 15, 1916 Sept. 20, 1916 Oct. 1, 1916 Dec. 12, 1917 July 8, 1919 July 10, 1919 July 14, 1919 Mar. 8, 1922	Lbs. 51.2 82.0 82.1 58.0 74.1 80.4 73.6 50.8 170.0	Lbs. 44.8 71.6 72.2 48.7 48.7 54.0 50.8 100.0	Gal- lons 50.0 52.0 52.0 39.4	Grams per liter 57.6 43.1	Gal- lons 33.8 39.4	Grams per liter 47.4 21.4	Grams per liter 40.2 21.4	Min- utes 20 25	Lbs. 100 100	° C. 62 70	Grams per liter 73.2 62.6	Lbs. 3.5 7.5	Gal- lons 20.2 24.3	Per cent 93.4 91.2			

	231	Jan. 15, 1918	91.0	72.0	50.1	99.6	41.4	85.9	35	108	88	130.4	16.6	15.3
Loblolly pine (<i>Pinus taeda</i>)	239	Apr. 7, 1920	164.7	79.2	73.6	---	---	---	---	---	---	60.1	16.1	5.9
	240	Apr. 8, 1920	166.7	77.6	73.2	---	---	---	---	---	---	90.0	33.0	44.2
	263	Apr. 13, 1920	161.4	79.6	73.6	---	---	---	---	---	---	60.1	25.0	10.0
	264	Apr. 15, 1920	164.9	82.2	73.6	---	---	---	---	---	---	77.3	17.9	4.8
	780	Jan. 14, 1921	83.8	82.6	82.6	---	---	---	---	---	---	25.6	21.7	32.1
Lodgepole pine (<i>Pinus contorta</i>)	824	Jan. 27, 1922	117.0	100.0	88.4	82.0	43.8	73.0	30	105	23	69.0	15.0	5.0
	54	Aug. 11, 1916	80.0	70.3	50.0	64.6	37.0	52.5	20	110	36	84.5	34.3	6.9
	55	Aug. 12, 1916	80.0	68.8	50.0	65.0	37.0	50.9	20	55	41	97.3	17.0	6.4
	216	Dec. 3, 1917	72.2	62.8	50.0	89.6	37.3	78.1	15	98	46	113.8	20.9	6.9
	5	Apr. 20, 1909	25.0	21.8	89.6	---	---	---	---	---	---	90.0	28.0	22.0
Longleaf pine (<i>Pinus palustris</i>)	113	Oct. 7, 1915	100.0	89.5	50.0	88.8	36.2	72.0	20	105	92	128.5	15.8	14.8
	201	Oct. 1, 1915	70.0	59.8	---	---	---	---	---	---	---	66.4	33.2	6.1
	209	Oct. 1, 1915	57.2	50.0	---	---	---	---	---	---	---	60.0	30.0	22.1
	210	Oct. 6, 1915	57.5	50.0	---	---	---	---	---	---	---	60.0	30.0	7.5
	212	Oct. 15, 1915	64.5	50.0	---	---	---	---	---	---	---	62.5	30.0	15.1
Monterey pine (<i>Pinus radiata</i>)	215	Oct. 25, 1915	64.4	50.0	---	---	---	---	---	---	---	270.0	20.1	5.0
	216	Oct. 26, 1915	64.0	50.0	---	---	---	---	---	---	---	365.0	30.0	24.0
	223	Nov. 19, 1915	125.6	104.5	49.7	36.9	18.9	28.5	15	100	70	47.0	16.2	6.0
	232	Dec. 10, 1915	124.1	100.0	47.7	96.2	45.3	61.0	25	105	97	157.0	38.7	2.4
	236	Dec. 21, 1915	118.3	100.0	49.2	71.7	39.4	60.1	38	8	5	87.5	35.4	5.0
Norway pine (<i>Pinus resinosa</i>)	246	Jan. 13, 1916	418.6	175.0	42.0	50.0	26.6	27.8	25	105	---	108.3	26.9	4.8
	241	Feb. 3, 1916	194.4	101.6	39.5	87.8	50.8	38.1	35	100	97	140.3	40.8	2.0
	242	Feb. 13, 1916	155.8	101.2	41.6	87.0	47.3	33.0	44	2	4	124.5	47.6	4.2
	243	Apr. 27, 1916	87.7	63.0	37.3	66.7	36.0	52.7	30	105	100	87.2	34.2	5.9
	244	Oct. 20, 1916	84.4	65.8	47.0	67.5	32.4	20.8	20	100	89	82.0	30.4	5.2
Pitch pine (<i>Pinus rigida</i>)	251	Oct. 25, 1916	86.4	72.9	50.0	58.8	33.5	39.1	44	8	3	97.0	29.0	4.1
	254	Oct. 27, 1917	119.0	105.0	40.4	54.5	32.7	31.6	33	7	20	105.8	25.6	2.8
	126	Apr. 31, 1917	81.0	71.2	50.0	46.6	35.0	34.2	25	100	85	138.0	42.2	3.5
	719	Jan. 12, 1921	100.3	78.9	---	---	---	---	15	100	54	91.0	46.6	5.6
	811	June 1, 1921	99.7	79.4	---	---	---	---	---	---	---	80.0	25.1	30.0
Pond pine (<i>Pinus rigida serotina</i>)	137	June 1, 1917	112.0	59.8	00.0	56.0	41.1	43.0	10	115	50	67.9	25.4	6.2
	158	July 18, 1917	75.2	58.5	50.0	70.0	37.9	60.5	25	105	94	85.6	14.4	5.4
	165	July 27, 1917	80.2	57.3	50.0	56.0	40.0	47.6	38	9	7	71.5	34.9	12.7
	771	June 1, 1921	54.9	44.2	---	---	---	---	10	102	76	74.7	24.8	6.2
	772	June 2, 1921	50.4	48.7	---	---	---	---	---	---	---	100.2	25.0	30.0
Sand pine (<i>Pinus clausa</i>)	208	Nov. 27, 1917	85.0	69.2	50.0	60.0	41.5	47.6	20	100	08	98.9	47.6	6.0
	700	Nov. 8, 1920	77.3	67.8	---	---	---	---	---	---	---	77.5	20.0	5.0
	12	Nov. 12, 1920	175.0	86.1	---	---	---	---	---	---	---	103.5	28.4	33.0
	893	Apr. 12, 1923	113.2	100.0	66.0	94.0	42.7	82.6	30	120	20	100.0	22.5	26.9
	895	Apr. 13, 1923	113.5	100.0	08.0	125.0	56.4	108.2	30	120	3	96.0	24.0	5.0
Scotch pine (<i>Pinus sylvestris</i>)	178	Nov. 14, 1912	40.5	32.2	---	---	---	---	30	120	20	62.4	20.0	20.0
	270	Sept. 10, 1920	82.7	71.6	---	---	---	---	---	---	---	90.0	30.6	8.6
	271	Sept. 13, 1920	90.6	77.3	---	---	---	---	---	---	---	76.4	24.0	21.6
	795	Sept. 14, 1920	87.8	76.0	---	---	---	---	---	---	---	99.9	24.0	5.0
	272	Sept. 14, 1920	87.8	76.0	---	---	---	---	---	---	---	99.9	24.8	29.9

Foot notes at end of table.

Cooking data—Continued										Strength data													
Species	Shipment No.	Cook No.	Date	Steam			Yields based on oven-dry weight of chips charged			Bleach required (35 per cent available chlorine) per 100 lbs.	Calendered	Weight per ream 24 x 36—500	Thickness	Mullen test per square inch	Strength factor per pound	Average stretch	Average breaking length	Average double folds	Average Elmendorf tearing test	Conditions during test			
				Maximum pressure per square inch	Pressure increased	Duration at maximum pressure	Crude pulp	Screenings	Oil per ton bone-dry chips											Relative humidity	Temperature		
Lumber pine (<i>Pinus flexilis</i>)	465	189	Oct. 15, 1917	100	20	135	47.0	.36			No.	41.5	3.7	24.9	1.12	2.48	3,810	1,323			61	64	
		193	Oct. 23, 1917	100	25	120	48.4	.23			No.	46.5	4.6	39.6	.70	2.77	5,010	1,540			61	64	
		717	Jan. 4, 1921	100	60	300	42.7	.43			N. B.	Yes	56.6	4.9	33.9	.65	2.54	5,746					
		718	Jan. 6, 1921	100	60	300	46.3	.36			N. B.	Yes	51.9	4.4	33.9	1.20	3.00	7,450					
		726	Jan. 24, 1921	95	60	320	46.3	.36	2.09			N. B.	No.	45.5	3.7	48.4	1.14	5.10	7,110	2,638			
Piñon (<i>Pinus edulis</i>)	792	727	Feb. 3, 1921	100	60	375	37.9				Yes	46.0	5.6	24.9	.54	2.48	3,810	368					
		728	Feb. 16, 1921	100	45	360	34.5				N. B.	Yes	56.6	4.9	33.9	.70	2.77	5,010	1,200				
		127	Apr. 27, 1917	90	10	150	50.4	.11			N. B.	Yes	51.9	4.4	33.9	.65	2.54	5,746	1,189				
		109	Oct. 30, 1917	100	15	150	47.4	.03			N. B.	No.	45.5	4.4	54.6	1.20	3.00	7,450	1,638				
		723	Jan. 11, 1918	105	20	300	44.0	.06			N. B.	No.	42.5	3.7	48.4	1.14	5.10	7,110	2,638				
Sugar pine (<i>Pinus lambertiana</i>)	455	723	Jan. 19, 1921	100	60	300	35.2				N. B.	No.	39.5	3.2	35.6	.90	3.60	6,850	1,042				
		139	June 5, 1917	90	15	155	51.4	.10			N. B.	Yes	43.5	3.9	58.0	1.33	3.90	4,025	1,320				
		195	Oct. 24, 1917	100	25	150	48.8	.04			N. B.	No.	41.5	3.9	55.3	1.33	4.10	7,100	1,836				
		729	Feb. 17, 1921	100	60	300	38.0	.10			N. B.	Yes	49.1	3.7	41.8	.85	2.92	6,457	703				
		730	Feb. 18, 1921	100	60	375	37.1					N. B.	Yes	54.8	4.1	45.3	.83	3.05	7,212	514			
Northern white pine (<i>Pinus strobus</i>)	501	21	Apr. 11, 1916	80	15	180	48.6	.76	1.20		No.	47.0	4.8	54.0	1.15	3.86	7,090	1,613					
		22	Apr. 13, 1916	75	15	180	45.0	.35	.80		No.	49.0	4.1	52.9	1.08	3.75	7,720	1,312					
		24	Apr. 17, 1916	80	15	180	47.9	.80	1.10		No.	44.0	4.4	66.9	1.52	4.53	7,800	2,718					
		77	Aug. 18, 1916	120	40	90	51.4	10.90			No.	39.0	3.9	46.8	1.20	4.65	6,620	1,298					
		85	Sept. 6, 1916	80	35	180	48.6	3.20			No.	43.5	4.4	63.5	1.46	3.75	6,370	1,410					
Jack pine (<i>Pinus banksiana</i>)	431	89	Sept. 13, 1916	100	55	185	55.2	11.00			No.	42.5	4.8	49.3	1.16	2.90	6,250	704					
		90	Sept. 15, 1916	100	45	130	48.7	2.25			No.	40.5	3.8	50.2	1.24	2.40	4,570	1,280					
		92	Sept. 20, 1916	100	45	140	56.5	15.35			No.	39.0	7.4	57.8	1.98	2.30	4,705	1,808					
		100	Oct. 5, 1916	100	35	210	49.6	2.98			No.	59.0	5.0	57.8	.98	2.30	4,705	1,808					
		222	Dec. 12, 1917	95	30	45	96.4				No.	40.0	4.0	50.8	1.27	4.10	6,900	1,383					
Jack pine (<i>Pinus banksiana</i>)	431	249	July 8, 1919	100	60	180	42.1				No.	41.5	3.4	34.0	.82	4.19	7,130	1,147					
		247	July 10, 1919	100	60	180	50.9				No.	38.0	4.0	29.0	.76	3.28	5,778	267					
		251	July 14, 1919	100	60	180	64.4				No.	41.5	4.2	34.5	.83	4.56	5,735	629					
		836	Mar. 8, 1922	100	50	240	37.0					No.	42	3.0	34.5	.83	4.56	5,735	629				
		501	Mar. 8, 1922	100	50	240	37.0					No.	42	3.0	34.5	.83	4.56	5,735	629				

Footnotes at end of table.

TABLE 9.—Cooking and strength data: The pines—soda or sulphate process—Continued

Species	Cooking data—Continued				Strength data										Condi- tions dur- ing test						
	Shipment No.	Cook No.	Date		Steam			Yields based on oven-dry weight of chips charged			Calendered	Weight per ream 24 x 36—500	Thickness	Mullen test per square inch	Strength factor per pound	Average stretch	Average breaking length	Average double folds	Average Elmendorf tearing	Temperature	
			Maximum pres- sure per square inch	Pressure increased	Duration at maxi- mum pressure	Crude pulp	Screenings	Oil per ton bone-	Bleach required (35 per cent available chlorine) per 100 pounds oven-dry pulp	Per cent										° F	Relative humidity
Loblolly pine (<i>Pinus taeda</i>)	801	231 259 260 263 264 780 824	Jan. 15, 1918 Apr. 7, 1920 Apr. 8, 1920 Apr. 13, 1920 Apr. 15, 1920 June 14, 1921 June 27, 1922	100 100 100 106 103 100 106	20 180 135 120 105 75 60	305 60 315 360 360 240 300	50.2 39.8 35.5 38.5 35.0 41.5 39.9	34 06 02 20 20 41.5 1.66	2.0 — — — — — —	65 24 20 25 20 35 N. B.	55.7 — — — — 55.7 44.4	6.1 — — — — 5.7 3.9	35.6 — — — — 42.4 23.6	.64 — — — — .76 .53	3.30 — — — — 3.60 4.10	4,650 — — — — 4,943 1,707	448 — — — — 553 67	— — — — — 57 1,398	— — — — — 66 84	72 69	66 61
	323	1216 1113 201 209 210 212 215 216 223 232 236 241 242 243 244	Dec. 3, 1917 Apr. 20, 1909 Oct. 7, 1915 Oct. 1, 1915 Oct. 6, 1915 Oct. 15, 1915 Oct. 25, 1915 Oct. 26, 1915 Nov. 19, 1915 Dec. 10, 1915 Dec. 21, 1915 Jan. 3, 1916 Feb. 13, 1916 Apr. 27, 1916 do.	100 110 100 90 80 80 100 100 110 90 90 80 80 80 80 80	20 45 35 25 40 30 30 30 35 60 60 45 25 10 25	270 54.2 105 190 180 190 120 120 140 180 160 150 180 180 180 180	54.2 49.2 48.3 48.3 49.1 44.9 44.2 60.5 41.1 46.6 40.4 43.4 42.7 52.5 24.9	2.87 2.0 — — — 3.76 1.25 — — 1.64 2.02 44 7.05 — — —	2.0 — — — — 3.76 1.25 — — 1.64 2.02 11.40 — — —	41 — — — — — — — — 30 — — — — — —	39.2 38.2 47.4 47.4 40.4 44.2 60.5 49.0 41.1 46.6 40.4 43.4 42.7 52.5 24.9	3.2 2.0 4.9 3.6 4.1 3.7 5.7 6.0 6.2 4.6 4.4 4.4 4.0 4.0 4.0	48.6 48.6 21.4 37.6 42.3 44.8 37.9 38.5 38.5 56.5 49.0 47.0 46.0 40.0 33.7 25.0	1.03 2.99 .59 .93 .88 .96 .98 1.00 1.15 1.15 .78 1.01 — — — — —	2.99 2.00 3.15 3.04 2.62 3.49 2.34 2.77 2.44 3.44 3.44 2.41 3.06 3.83 3.30						

Monterey pine (<i>Pinus radiata</i>).	719	Oct. 31, 1917	100	105	360	43.2	.13		N. B.	48.1	4.7	49.5	1.03	3.60	5,670	2,191	75	55	
	720	Jan. 12, 1921	91	75	360	40.9	.34		N. B.	78.2	10.4	48.0	.61	2.04	3,537	422	65	87	
	137	June 1, 1917	90	20	165	53.8	.13		Yes	54.0	4.6	65.4	1.21	4.10	7,365	1,375	66	72	
Norway pine (<i>Pinus resinosa</i>).	158	July 18, 1917	100	15	180	50.8	.00		No	113.0	9.6	76.9	1.68	4.80	4,810	1,906	66	88	
	165	July 27, 1917	110	25	120	48.3	1.96	.05	No	46.5	4.1	50.3	1.08	3.30	6,880	1,170	68	78	
	771	June 1, 1921	100	70	300	36.7			Yes	60.4	4.2	29.0	.48	3.87	4,186	41	51	65	
	772	June 2, 1921	100	70	300	40.7			N. B.	38.0	3.2	16.5	.43	2.10	3,700	104	50	66	
	208	Nov. 27, 1917	102	15	175	48.9	.13	.32	No	51.0	4.4	55.1	1.08	4.60	6,960	1,236	66	93	
Pitch pine (<i>Pinus rigida</i>).	700	Nov. 8, 1920	100	45	360	38.6			Yes ¹³	51.9	4.0	29.2	.56	1.94	4,144	38	66	72	
	12	Nov. 12, 1920	100	90	360	36.9			27										
Pond pine (<i>Pinus rigida serotina</i>).	883	Apr. 12, 1923	100	75	300	42.7			N. B.										
	884	Apr. 13, 1923	100	75	300	40.6			30										
Sand pine (<i>Pinus clausa</i>).	895	Apr. 16, 1923	100	75	180	48.6			N. B.	131.8	13.0	96.7	.73	3.64	4,889	4,890	597	65	
	11	Nov. 14, 1912	100	60	480	40.1	1.00		(¹⁴)									72	
Scotch pine (<i>Pinus sylvestris</i>).	270	Sept. 10, 1920	100	70	270	34.5			13 21										
	271	Sept. 13, 1920	100	75	240	41.4			Yes	49.0	3.7	37.4	.76	2.32	5,788	608	66	72	
	272	Sept. 24, 1920	115	95	300	36.1			36										
Virginia pine (<i>Pinus virginiana</i>).	17	Nov. 22, 1920	100	120	330	33.6			22										
	16	Nov. 19, 1917	100	25	175	47.4	.11	.40	16										
Shorleaf pine (<i>Pinus echinata</i>).	207	Mar. 20, 1917	90	15	165	50.9	.03		No	52.9	4.4	48.7	.92	5.00	6,390	1,413	63	72	
	703	Nov. 15, 1920	100	120	270	41.7			No	49.0	5.1	40.2	.82	4.00	5,480	4,458	65		
	704	Nov. 17, 1920	100	75	360	37.1			30										
Slash pine (<i>Pinus caribaea</i>).	267	Aug. 5, 1920	100	75	360	37.9			N. B.	42.5	2.9	18.6	.44	1.78	3,771	31	65	87	
	268	Sept. 8, 1920	100	90	240	48.7			16 28	Yes ¹⁵	40.5	3.9	25.7	.63	2.25	5,155	921	66	73
	269	Sept. 9, 1920	117	70	300	37.0			N. B.										
	8	Feb. 2, 1916	80	45	180	43.4	.10		No	44.0	3.9	73.5	1.67	3.05	10,750	497			
	115	Feb. 21, 1917	100	20	120	46.2			No	42.5	4.1	43.0	1.01	3.60	6,780	1,378	66		
Western yellow pine (<i>Pinus ponderosa</i>).	117	Feb. 26, 1917	80	20	180	54.1	.30		No	49.0	4.2	57.8	1.18	4.60	7,660	681	65		
	118	Mar. 8, 1917	100	25	135	53.6	.44		No	35.8	4.1	47.3	1.32	3.00	7,840	778	67		
	170	Aug. 4, 1917	90	10	170	44.0	.24		No	38.5	3.4	32.0	.83	3.40	6,080	770	67	85	
	781	June 15, 1921	100	90	300	36.3			N. B.	74.6	6.8	54.1	.73	2.77	4,800	2,738	65	92	
	14	May 3, 1911	70	60	480	54.0	.07		Yes	15.0	1.1	17.7	1.18						
	291	May 29, 1918	100	70	180	46.5	.10		Yes ¹⁶	43.5	3.4	22.8	.52	2.93	4,862	249	66	83	
	292	June 5, 1918	100	40	300	43.5	.10		No	58.5	5.2	31.6	.54	2.88	4,575	462	66	81	
	243	June 10, 1918	100	40	170	49.0	.37		No	36.0	3.9	26.9	.75	3.20	5,040	517	65	82	

¹ Recook of pulp from soda cook with 45 per cent yield.

² 23.3 g. p. l. Na₂ CO₃ in cooking liquor.

³ 44.1 g. p. l. Na₂ CO₃ in cooking liquor.

⁴ Lightwood used.

⁵ Water-soaked chips.

⁶ Equal parts water-soaked and air-dry chips mixed.

⁷ Unbarked wood; 96 per cent wood, 4 per cent bark.

⁸ Bark only; pulp bluish and unscreenable.

⁹ Yaryan process extracts chips retained on 12-mesh screen (70 per cent).

¹⁰ Unextracted chips retained on screen (64 per cent).

¹¹ Pulp of good quality. Not run into paper.

¹² 22 gallons distilled during pressure increase period.

¹³ 12 per cent bleach in two steps.

¹⁴ Paper of fair strength; no strength tests recorded.

¹⁵ 18 per cent bleach in two steps.

¹⁶ Paper made from bleached pulp.

¹⁷ 16 per cent bleach in two steps.

¹⁸ Waterleaf sheet of pulp.

TABLE 10.—Cooking and strength data: The first—Sulphite process

Species	Ship- ment No.	Cook No.	Date	Quantity of wood used		Cooking liquor				Cooking data					Cooking period			
				Moist weight	Oven- dry weight	Composition			Per 100 pounds chips		Time to maxi- mum tem- per- ature	Time to maxi- mum pres- sure	Dura- tion of cook	Maxi- mum tem- per- ature	Maxi- mum pres- sure per square inch	Gas pres- sure at blow per square inch		
						Total	Free	Com- bined	Volume	SO ₂								
				Pounds	Pounds	Per cent	Per cent	Per cent	Gallons	Per cent	Hours	Hours	Hours	° C.	Pounds	Pounds		
Alpine fir (<i>Abies lasiocarpa</i>)	271-3	487	Oct. 28, 1920	77.0	66.0	5.35	4.07	1.28	86.0	—	7.75	6.00	8.00	152	82	4		
		494	Nov. 12, 1920	79.2	68.8	5.38	4.30	1.08	81.8	—	8.00	14.25	8.00	153	100	10		
		497	Nov. 17, 1920	77.0	57.7	5.20	4.07	1.13	84.4	—	8.00	4.00	8.00	148	94	9		
Balsam fir (<i>Abies balsamea</i>)	501	345	Oct. 1, 1917	66.2	61.6	5.56	4.10	1.46	—	—	8.00	3.25	8.00	154	90	10		
		349	Oct. 18, 1917	68.5	58.1	5.41	4.05	1.36	—	—	7.75	3.25	8.50	152	90	8		
		354	Nov. 8, 1917	66.9	56.9	5.42	4.27	1.15	—	—	7.75	3.25	7.75	152	100	10		
Lowland white fir (<i>Abies grandis</i>)	490	337	July 12, 1917	88.0	55.1	5.70	4.35	1.35	—	—	7.00	1.50	7.00	152	100	22		
		338	July 13, 1917	88.0	55.1	5.80	4.62	1.18	—	—	8.50	3.25	8.50	154	90	6		
		341	July 18, 1917	71.8	51.5	5.55	4.42	1.13	—	—	7.75	2.50	7.75	154	110	10		
Noble fir (<i>Abies nobilis</i>)	271-1	498	Nov. 18, 1920	103.8	50.8	5.10	4.05	1.05	104.0	—	8.00	4.25	8.00	149	100	8		
		304	Nov. 10, 1916	78.0	70.0	5.34	4.08	1.26	—	—	7.00	2.00	7.75	141	80	30		
		594	June 14, 1921	72.8	65.4	5.29	4.04	1.25	87.4	—	8.00	3.50	8.00	153	100	10		
Red fir (<i>Abies magnifica</i>)	271-2	326	Jan. 4, 1917	74.0	63.7	5.50	4.30	1.20	—	—	7.45	2.75	7.75	144	94	40		
		524	Jan. 26, 1921	61.8	54.1	5.25	4.00	1.25	—	—	8.00	4.50	8.00	153	100	10		
		353	Oct. 24, 1917	89.8	58.0	5.64	4.48	1.16	—	—	8.25	2.50	8.25	151	86	6		
Silver fir (<i>Abies amabilis</i>)	35-37	356	Nov. 12, 1917	74.4	50.2	5.46	4.40	1.06	—	—	7.75	4.00	8.00	152	100	9		
		8	Mar. 3, 1908	60.0	48.9	4.01	3.05	.96	20.5	20.5	7.00	—	9.00	153	—	—		
		525	Jan. 27, 1921	56.2	49.1	5.46	4.26	1.20	126.6	42.3	8.00	4.25	8.00	152	100	10		
White fir (<i>Abies concolor</i>)	455	429	Mar. 22, 1920	75.5	66.5	5.52	4.22	1.30	88.7	42.3	8.25	4.25	8.25	153	100	10		
		439	Apr. 8, 1920	78.2	68.8	5.50	4.40	1.10	89.9	43.4	7.75	2.75	7.75	161	100	4		
		557	Mar. 23, 1921	70.5	62.8	5.51	3.99	1.52	99.5	—	8.00	4.25	8.00	157	100	12		
Douglas fir (<i>Pseudotsuga taxifolia</i>)	338																	

Species	Cooking data—Continued				Strength data										Conditions during test	
	Ship-ment No.	Cook No.	Date	Yields based on oven-dry weight of chips charged		Bleach require-ment (35 per cent available chlorine) per 100 pounds oven-dry pulp	Weight per ream 24 x 36—500	Thick-ness 0.001 in.	Mullen test per square inch	Strength factor per pound ream	Aver- age stretch	Aver- age break- ing length	Aver- age double- fold	Aver- age Elmen- dorf tearing test	Rela- tive humid- ity	Tem- perature
				Crude pulp	Per cent	Pounds	Pounds	0.001 in.	Pounds	Points	Per cent	Meters		Grams	Per cent	° F.
Alpine fir (<i>Abies lasiocarpa</i>)	271-3	487	Oct. 28, 1920	49.2	.40	16	Yes	3.3	45.6	.91	2.20	7.039	683	---	63	77
		494	Nov. 12, 1920	45.5	.30	10	Yes	3.5	37.7	.80	1.98	6.625	693	---	65	70
		497	Nov. 17, 1920	49.0	.29	26	Yes	3.8	40.8	.80	1.93	6.902	1,291	---	64	69
Balsam fir (<i>Abies balsamea</i>)	501	345	Oct. 1, 1917	44.5	.28	20	Yes	2.8	29.6	.75	3.40	6.655	1,192	---	64	82
		349	Oct. 18, 1917	48.1	.12	30	Yes	3.5	35.0	.92	3.68	6.677	1,109	---	65	77
		354	Nov. 8, 1917	48.0	.10	26	Yes	4.1	45.0	1.01	3.12	7.068	918	---	63	76
		337	July 12, 1917	43.4	1.30	24	Yes	4.3	21.1	.49	2.65	4.400	220	---	---	---
		338	July 13, 1917	48.5	.22	17	Yes	4.5	30.0	.67	2.52	5.550	684	---	65	95
Lowland white fir (<i>Abies grandis</i>)	490	341	July 18, 1917	49.6	.44	24	Yes	4.2	30.1	.71	2.65	5.730	740	---	66	96
		498	Nov. 18, 1920	55.1	.70	30	Yes	3.9	42.9	.80	2.43	6.639	644	---	65	70
		507	Dec. 15, 1920	48.8	---	22	Yes	3.8	28.0	.73	1.53	6.100	248	---	60	---
Noble fir (<i>Abies nobilis</i>)	271-1	304	Nov. 10, 1916	55.8	.66	45	Yes	4.2	32.9	.69	1.75	6.262	324	---	65	94
		594	June 14, 1921	46.4	.16	10	Yes	3.1	34.8	.80	2.05	5.262	1,324	---	65	---
Red fir (<i>Abies magnifica</i>)	---	326	Jan. 4, 1917	51.1	1.11	35	Yes	3.7	47.5	1.14	1.82	7.250	720	---	65	---
		524	Jan. 26, 1921	48.2	.25	20	Yes	3.7	55.5	1.30	1.75	8.206	845	---	65	70
Silver fir (<i>Abies amabilis</i>)	271-2	353	Oct. 24, 1917	48.7	.13	30	Yes	3.8	29.3	.69	2.62	5.860	717	---	64	74
		356	Nov. 12, 1917	50.8	.13	27	Yes	3.7	34.8	.86	2.41	6.315	730	---	64	75
		8	Mar. 3, 1908	42.1	.70	13	(^c)	---	---	---	---	---	---	---	---	---
White fir (<i>Abies concolor</i>)	35-37	525	Jan. 27, 1921	49.3	.35	25	Yes	3.4	39.5	.86	2.20	6.510	665	---	65	72
	455	429	Mar. 22, 1920	59.2	5.18	(^e)	Yes	3.6	15.3	.37	1.41	4.156	71	---	65	72
Douglas fir (<i>Pseudotsuga taxifolia</i>)	338	439	Apr. 8, 1920	48.8	.82	---	Yes	3.6	23.2	.50	1.80	3.806	80	---	66	76
		557	Mar. 23, 1921	42.6	4.14	22	Yes	3.6	18.3	.38	1.58	3.781	161	---	66	74

¹ Gas pressure held 1½ hours on account of stopped relief valve.² Gas pressure held 2 hours.³ Pulp very shivy.⁴ Pulp apparently of excellent strength; not run into paper.⁵ Unbleached pulp of excellent color and quality.⁶ Unbleached pulp decidedly yellow.

Cooking data—Continued				Strength data												Conditions during tests						
Species	Shipment No.	Cook No.	Date	Steam			Yields based on oven-dry weight of chips charged			Calendered	Weight per ream 24 x 36—500	Thickness	Mullen test per square inch	Strength factor per pound	Average stretch		Average breaking length	Average double folds	Average Elmhurst tearing test	Temperature		
				Maximum pressure per square inch	Pressure increased	Duration at maximum pressure	Crude pulp	Screenings	Oil per ton bone-dry chips											Bleach required (35 per cent available chlorine) per 100 pounds oven-dry pulp	° F.	Relative humidity
Alpine fir (<i>Abies lasiocarpa</i>)	271-3	42	June 15, 1916	80	30	195	51.5	22.40	(1)	Lbs.	No.	41.5	3.7	43.6	1.05	3.57	7,020	628	Gms.	Per cent	64	
		43	June 16, 1916	80	15	180	50.6	1.13			No.	42.5	3.4	42.1	.99	4.56	7,240	1,015			69	
		44	June 19, 1916	80	30	180	49.5	.75			No.	38.0	3.2	48.6	1.28	4.41	8,000	1,058			67	
		701	Nov. 9, 1920	100	60	300	41.2				N. B.	24										
		705	Nov. 19, 1920	100	75	360	43.2				N. B.	24										
Balsam fir (<i>Abies balsamea</i>)	501	702	Nov. 10, 1920	100	75	240	27.3					40.5	3.6	62.0	1.53	2.86	10,220	778				
		3	Jan. 21, 1916	90	30	150	45.8				No.	38.0	3.7	49.8	1.31	3.15	7,550	729			65	
		183	Oct. 21, 1917	100	20	150	48.2	1.26			No.											72
		284	Oct. 5, 1920	100	60	300	41.2				No.	47.6	5.0	53.8	1.13	3.50	7,230	1,057			64	
		128	Apr. 30, 1917	100	25	165	49.7	.04			No.	38.0	3.8	42.2	1.11	3.50	7,230	1,083			62	
Lowland white fir (<i>Abies grandis</i>)	490	197	Oct. 26, 1917	100	25	165	49.7															
		710	Dec. 7, 1920	90	60	360	35.3				No.											
		711	Dec. 7, 1920	95	85	360	35.0				N. B.	20										
		30	May 11, 1916	80	15	180	49.5	.17			No.	40.5	3.2	39.7	.89	3.68	6,570	1,241			67	
		40	June 13, 1916	80	15	180	53.1	.44			No.	43.5	3.6	38.7	.87	3.32	6,150	1,116			65	
Noble fir (<i>Abies nobilis</i>)	271-1	778	June 10, 1921	100	65	300	40.9			24	Yes	61.4	5.4	53.2	.65	3.09	4,817	1,830			90	
		779	June 13, 1921	100	70	360	40.6			N. B.	51.9	4.5	33.9	.65	2.74	4,793	1,086			90		
		134	May 22, 1917	90	20	155	51.5	.00			N. B.	38.0	3.5	43.7	1.15	3.50	7,570	1,464			76	
		712	Dec. 9, 1920	100	90	300	39.2			35												
		713	Dec. 13, 1920	97	60	360	40.0			N. B.												
Silver fir (<i>Abies amabilis</i>)	271-2	34	June 2, 1916	80	30	140	46.6					43.5	3.9	37.0	.85	3.03	6,140	1,112			67	
		35	June 5, 1916	80	10	180	49.9	.64		N. B.	39.5	3.4	41.1	1.04	3.92	6,820	1,712			68		
		196	Oct. 25, 1917	100	20	150	52.2	.04		N. B.	41.5	4.1	47.8	1.15	3.59	6,930	1,683			67		
		253	Jan. 28, 1920	82	60	360	47.3			N. B.	35.0	3.0	22.1	.63	2.37	5,450	1,495			67		
		119	Mar. 9, 1917	90	25	160	51.8	.25		N. B.	36.0	3.0	23.9	.72	2.80	8,110	1,072			67		
White fir (<i>Abies concolor</i>)	455	201	Nov. 1, 1917	97	20	165	50.0	.07				41.5	3.9	50.7	1.22	4.50	6,700	1,256			62	
		714	Dec. 15, 1920	100	90	285	38.9			26												
		716	Dec. 20, 1920	100	60	360	35.4			N. B.												
		14	Feb. 25, 1916	100	30	180	42.0	.60		N. B.	51.5	5.15	52.6	1.02	2.31	7,750	711					
		15	Mar. 1, 1916	90	20	180	48.0	5.10		N. B.	47.0	4.62	53.1	1.13	2.73	8,560	488					
Douglas fir (<i>Pseudotsuga taxifolia</i>)	338											70.0	7.60	.38	2.00	3,290	345			95		
	796																				65	

* Waterleaf sheet of pulp.

† Chips thoroughly soaked with water.

‡ Chipped throughly soaked with water.

§ Condensate gave iodoform reaction.

¶ Relief gases had pleasant ketone-like odor.

TABLE 12.—Cooking and strength data: Hemlocks and other conifers—Sulphite process

Cooking data															
Species	Ship- ment No.	Cook No.	Date	Quantity of wood used		Cooking liquor					Cooking period				
				Moist weight	Oven- dry weight	Composition			Per 100 pounds chips		Time to maxi- mum tem- per- ature Hours	Dura- tion of cook- ing Hours	Maxi- mum tem- per- ature ° C.	Maxi- mum pres- sure per square inch Pounds	Gas pres- sure at blow per square inch Pounds
						Total	Free	Com- bined	Volume	SO ₂					
				Per cent	Per cent	Per cent	Gallons	Per cent	Hours	Hours	Hours	° C.	Pounds	Pounds	
Carolina hemlock (<i>Tsuga caroliniana</i>).	822	531	Feb. 7, 1921	91.4	60.3	5.60	4.35	1.25	104.7	---	8.00	3.25	8.00	153	10
		532	Feb. 8, 1921	82.6	59.0	5.20	4.10	1.10	105.4	---	8.00	3.75	8.00	153	4
		535	Feb. 13, 1921	85.6	61.3	5.45	4.32	1.13	101.8	---	7.00	3.00	7.00	153	4
Eastern hemlock (<i>Tsuga canadensis</i>).	910-A	600	Sept. 27, 1921	119.8	55.7	5.44	4.37	1.07	99.0	---	8.00	2.50	8.00	150	12
		604	Sept. 27, 1921	101.5	50.0	5.56	4.27	1.29	134.4	---	9.00	4.00	9.00	148	12
		652	Aug. 20, 1922	103.0	74.4	4.45	3.12	1.33	72.5	---	7.75	1.75	8.75	154	5.7
Western hemlock (<i>Tsuga heterophylla</i>).	325	404	Nov. 7, 1919	70.3	62.4	5.45	4.17	1.28	97.0	45.7	8.00	6.75	8.00	153	4
		406	Nov. 14, 1919	63.0	56.4	5.53	4.17	1.38	96.2	51.4	7.00	5.00	7.00	152	4
		412	Nov. 29, 1919	74.5	66.3	4.53	3.50	1.03	88.0	---	8.00	2.50	8.00	153	4
Tamarack (<i>Larix laricina</i>).	26-3	381	July 31, 1919	97.3	86.1	5.46	4.32	1.14	69.0	32.0	8.00	3.75	10.50	147	10
		576	Apr. 27, 1921	79.8	69.8	5.60	4.35	1.25	88.3	---	8.00	5.75	10.50	150	8
		482	Oct. 20, 1920	99.8	85.2	5.44	4.29	1.15	71.8	---	10.50	3.75	10.50	147	10
Western larch (<i>Larix occidentalis</i>).	277	555	Mar. 21, 1921	97.7	83.0	5.45	3.99	1.46	73.8	---	6.75	3.50	7.50	152	28
		459	Sept. 15, 1920	98.6	56.0	4.95	3.80	1.15	116.5	---	6.75	3.50	7.50	152	28
		439	Sept. 21, 1920	97.6	66.4	4.95	3.80	1.15	116.5	---	6.75	3.50	7.50	152	28
Incense cedar (<i>Libocedrus decurrens</i>).	803	461	Sept. 21, 1920	74.1	66.4	5.41	4.38	1.03	106.0	---	8.00	2.75	8.00	153	10
		417	Feb. 20, 1920	76.8	67.7	5.55	4.52	1.03	86.0	41.4	8.00	2.75	8.00	153	10
		523	Jan. 23, 1921	72.9	64.2	5.51	4.25	1.26	94.2	---	8.00	3.50	8.00	153	10
Port Orford cedar (<i>Chamaecyparis lawsoniana</i>).															
Eastern red cedar (<i>Juniperus virginiana</i>).	813	521	Jan. 20, 1921	89.6	78.7	5.56	4.25	1.31	74.3	---	8.00	5.50	8.00	154	8
		812	Feb. 9, 1921	61.3	52.8	5.56	4.38	1.18	109.9	---	8.00	3.75	8.00	153	10
		533	July 29, 1919	57.1	50.9	4.37	3.28	1.09	114.0	43.3	8.00	3.75	8.00	153	10
Western red cedar (<i>Thuja plicata</i>).	368	379	Mar. 2, 1921	71.2	62.2	5.18	3.92	1.26	95.6	---	8.00	4.50	8.00	158	9
		544	Mar. 2, 1921	71.2	62.2	5.18	3.92	1.26	95.6	---	8.00	4.50	8.00	158	9
		435	Mar. 31, 1920	65.7	58.3	4.50	3.40	1.10	102.0	39.5	7.00	4.25	7.00	153	4
Redwood (<i>Sequoia sempervirens</i>).	520	441	Apr. 16, 1920	66.0	59.3	3.66	2.56	1.10	94.0	60.2	8.00	5.80	8.00	153	4

Cooking data—Continued				Strength data										Conditions during test			
Species	Shipment No.	Cook No.	Date	Yields based on oven-dry weight of chips charged		Bleach required (35 per cent available chlorine) per 100 pounds oven-dry pulp	Calendered 24x36—500	Weight per ream	Thick-ness	Mullen test square inch	Strength factor per pound per ream	Average stretch	Average breaking length	Average double folds	Average Elemen-dorf tearing test	Relative humid-ity	Tem-pera-ture
				Crude pulp	Screen-ings												
				Per cent	Per cent	Pounds		Pounds	0.001 in.	Pounds	Points	Per cent	Meters		Grams	Per cent	° F.
Carolina hemlock (Tsuga caroliniana).	822	531	Feb. 7, 1921	42.9	0.57	21	Yes	43.5	3.4	30.6	0.70	2.31	5,742	370		65	70
		532	Feb. 8, 1921	38.2	.45	22	Yes	55.7	4.3	45.7	.82	2.47	6,244	637		64	72
		535	Feb. 15, 1921	43.0	.70	27	Yes	44.5	3.1	24.4	.55	1.77	5,146	320	140	66	72
		600	Sept. 21, 1921	42.2	.81	24	Yes	53.8	4.0	41.2	.77	3.01	6,762	535	228	64	69
Eastern hemlock (Tsuga canadensis).	910-A	604	Sept. 27, 1921	42.8	4.4	28	Yes				.92						
		652	Aug. 20, 1922	48.6			(1)										
Western hemlock (Tsuga heterophylla).	325	404	Nov. 7, 1919	49.7	.57	17	Yes	43.5	3.1	32.6	.75	2.76	7,015	1,286		65	73
		406	Nov. 14, 1919	49.7	.10	26	Yes	55.0	4.0	46.0	.84	3.01	7,100	1,488		67	69
		412	Nov. 29, 1919	43.4	4.52	17	Yes	39.6	2.9	24.6	.62	2.98	6,055	589		64	71
		381	July 31, 1919	38.4	.30	30	Yes	63.0	4.3	18.1	.29	1.91	3,390	990		65	71
Tamarack (Larix laricina).	26-3	576	Apr. 27, 1921	42.2	.61	16	Yes	60.5	4.2	31.7	.52	2.48	4,087	371		66	71
Western larch (Larix occi-dentalis).	277	482	Oct. 20, 1920	43.7	14.10	33	Yes	41.5	2.9	20.6	.50	1.32	4,196	75		65	81
		555	Mar. 21, 1921	40.6	3.86	18	Yes	58.0	4.8	28.6	.49	1.82	4,285	114		67	75
		459	Sept. 15, 1920	40.7	.14	42	Yes	38.0	2.6	27.3	.72	2.08	6,295	815		64	82
		461	Sept. 21, 1920	44.8	4.00	42	Yes	49.1	3.0	35.8	.73	2.60	6,695	597		66	74
Incense cedar (Libocedrus decurrens).	803	417	Feb. 20, 1920	43.3	1.55	30	Yes	36.2	2.5	18.0	.50	2.58	6,091	390		67	79
		523	Jan. 23, 1921	49.7	.80	28	Yes	39.5	3.1	45.3	1.15	1.90	8,014	879		66	70
		521	Jan. 20, 1921	56.3		N.B. ³	Yes	47.0	4.9	18.4	.39	.95	3,332	8		65	71
		533	Feb. 9, 1921	43.5	.69	N.B.	Yes	37.0	2.6	25.9	.70	1.33	7,031	340		65	73
Southern cypress (Taxo-dium distichum).	308	379	July 29, 1919	47.8	.73	32	Yes	55.7	4.1	25.1	.45	3.03	4,285	185		66	82
		544	Mar. 2, 1921	44.6	1.60	24	Yes	47.0	4.0	21.4	.46	1.61	4,132	111	138	64	70
		435	Mar. 31, 1920	50.6	1.78	N.B.	Yes	64.0	6.1	64.0	1.00	2.34	6,675	602		64	76
		441	Apr. 16, 1920	51.7	4.42	N.B.	Yes	60.0	5.8	58.5	.98	1.75	5,828	342		64	76

³ Pulp raw, brash, and very dark colored.

² Paper very brash and dirty.

¹ Hand sheet from pulp ground in ball mill for 60 minutes.

TABLE 13.—Cooking and strength data: Hemlocks and other conifers—Soda or sulphate process

Species	Shipment No.	Cook No.	Date	Quantity of wood used		Cooking data						Cooking liquor				Black liquor ratio combined to total alkali				
				Moist weight	Oven-dry weight	Before penetration			After penetration			Penetration		Concentration	Per 100 pounds bone-dry chips					
						Volume	Concentration		Volume	Concentration		Duration	Pressure per square inch		Temperature					
							NaOH	Na ₂ S		NaOH	Na ₂ S						NaOH	Na ₂ S	Grams per liter	Lbs.
Eastern hemlock (<i>Tsuga canadensis</i>).	226	{	5	Jan. 25, 1961	73.4	65.5	36.0	70.0	46.5	38.0	30	100	90	106.2	18.1	6.9	20.4	86.1		
			11	Feb. 16, 1916	88.6	75.0	49.4	67.5	36.7	34.3	50.4	15	110	84	100.0	37.2	6.2	24.0	88.9	
			51	Mar. 30, 1916	78.0	68.3	52.0	65.0	37.0	36.8	55.1	37.0	15	100	36	82.9	35.2	7.0	25.8	
			52	July 3, 1916	78.0	68.3	52.0	62.5	40.0	33.4	37.7	35.1	15	103	35	79.8	41.6	17.3	94.0	
			198	Oct. 29, 1917	70.4	61.4	50.0	49.6	35.0	36.5	37.7	35.1	20	98	51	73.3	32.4	15.6	27.2	82.0
Carolina hemlock (<i>Tsuga caroliniana</i>).	822	{	758	May 4, 1921	47.1	40.1		80.0		73.3		20	112	64	97.4	24.4	30.1	87.9		
			759	May 5, 1921	54.8	45.6									75.0	18.8	30.0	78.3		
			760	May 6, 1921	25.1	20.9									60.0	20.0	5.0	30.0	84.9	
			45	June 20, 1916	78.0	64.8	50.0	65.0	38.0	54.8	36.5	20	100	30	80.4	37.2	17.1	7.9	23.6	
			48	June 26, 1916	82.0	67.2	52.0	58.2	34.4	37.8	48.7	34.8	15	105	33	74.0	29.9	14.7	6.0	23.8
Western hemlock (<i>Tsuga heterophylla</i>).	325	{	49	June 27, 1916	82.0	66.9	52.0	57.5	40.0	39.2	15	105	35	78.7	37.6	15.4	7.7	24.5		
			108	Dec. 6, 1916	79.3	67.2	51.0	72.8		63.0		20	105	35	76.7	17.4	20.5	5.0	27.3	77.5
			721	Jan. 14, 1921	58.7	47.0									80.0	20.1		30.0	82.9	
			782	June 16, 1921	67.9	59.6									104.0	20.1		25.2	79.8	
			75	Aug. 15, 1916	84.0	76.0	50.0	70.4	49.5	59.6	51.4	20	110	61	99.8	38.6	13.0	5.1	15.6	
Tamarack (<i>Larix laricina</i>)	269E	{	78	Aug. 22, 1916	80.0	70.8	49.6	68.6	48.9	54.3	48.3	20	110	80	99.5	46.6	17.0	8.0	20.5	
			84	Sept. 1, 1916	70.4	62.6									73.5	27.7	16.3	6.1	26.6	
			756	May 7, 1921	80.3	74.5									105.5	26.4			77.7	
			757	May 13, 1921	85.6	78.0													89.0	
			16	Mar. 21, 1916	111.0	98.0	45.0	67.0	38.3	27.8	37.0	20	100	37	83.0	36.4	13.9	6.1	20.0	
Western larch (<i>Larix occidentalis</i>).		{	19	Mar. 24, 1916	96.0	82.8	48.0	70.0	40.0	50.5	38.0	20	100	90	138.0	42.0	13.5	4.1	11.7	
			755	Feb. 29, 1921	100.3	87.0									82.4	23.6	20.3	6.3	30.0	84.0
			276	Sept. 20, 1920	71.2	64.4									81.2	23.6	21.8	6.3	31.8	74.9
			277	Sept. 21, 1920	61.8	55.7									72.0	21.1	15.0	4.4	25.0	87.1
			278	Sept. 22, 1920	62.8	57.1									100.1	25.0			30.0	75.0

Port Orford cedar (<i>Chamaecyparis lawsoniana</i>).	532	722	Jan. 18, 1921	56.6	49.7	---	---	---	---	---	100.1	25.0	8.8	29.9	85.5
		724	Jan. 20, 1921	43.0	36.6	---	---	---	---	---	106.1	26.5	8.8	30.0	65.6
		725	Jan. 21, 1920	50.5	43.0	---	---	---	---	---	103.1	25.1	6.3	30.0	69.8
	Southern white cedar (<i>Chamaecyparis thyoides</i>).	897	May 18, 1923	83.2	75.0	---	---	---	---	---	93.4	25.0	12.5	32.2	67.3
		898	May 21, 1923	83.6	73.0	---	---	---	---	---	98.9	26.7	6.0	30.0	78.0
		899	May 23, 1923	33.5	30.1	---	---	---	---	---	51.9	23.9	13.0	30.0	83.0
	Eastern red cedar (<i>Juniperus virginiana</i>).	813	Oct. 12, 1920	74.0	64.6	---	---	---	---	---	75.0	24.9	18.8	6.2	30.0
		285	Nov. 2, 1920	86.0	73.8	---	---	---	---	---	64.9	20.0	16.2	5.0	30.0
		286	Nov. 3, 1920	87.0	74.6	---	---	---	---	---	100.6	25.0	25.0	29.8	83.5
	Western red cedar (<i>Thuja plicata</i>).	812	731	Feb. 21, 1921	56.8	48.9	---	---	---	---	98.3	24.4	25.0	18.7	29.8
732		Feb. 25, 1921	71.3	60.0	---	---	---	---	---	75.0	18.7	6.3	30.0	71.8	
733		Mar. 10, 1921	65.7	57.4	---	---	---	---	---	60.2	20.0	15.0	5.0	29.8	
398		136	May 20, 1917	69.6	61.9	50.0	36.2	31.4	10	42	70.0	13.9	6.3	23.8	
214		Nov. 28, 1917	70.4	61.6	50.0	36.5	82.8	15	100	55	101.1	20.0	23.7	73.0	
Redwood (<i>Sequoia sempervirens</i>).	8	785	June 22, 1921	81.3	69.2	---	---	---	---	---	75.0	18.8	6.3	30.0	81.2
		25	Apr. 4, 1912	54.6	50.9	---	---	---	---	---	89.8	25.0	---	33.4	78.7
Do.	520	180	Sept. 12, 1917	73.0	57.5	---	---	---	---	---	52.3	30.1	13.9	8.0	31.9
		192	Oct. 19, 1917	72.2	60.6	---	---	---	---	---	47.2	27.0	12.8	7.3	32.5
		784	June 21, 1921	65.6	59.3	---	---	---	---	---	75.0	25.0	18.8	6.3	30.0
		783	June 20, 1921	168.3	65.0	---	---	---	---	---	75.1	25.0	18.8	6.3	30.0
		793	Sept. 6, 1921	128.0	46.8	---	---	---	---	---	58.4	17.4	21.0	6.3	43.0

¹ Color of bleached pulp below standard.² Chips bleached 72 hours in warm water.

TABLE 14.—Cooking and strength data: Hardwoods—Diffuse porous—Sulphite process

Species	Ship- ment No.	Cook No.	Date	Quantity of wood used		Cooking liquor				Cooking period				
				Moist weight	Oven- dry weight	Composition			Per 100 pounds chips	Time to maxi- mum tem- per- ature	Dura- tion of cook- ing	Maxi- mum tem- per- ature	Maxi- mum pres- sure per square inch	Gas pres- sure at blow per square inch
						Total	Free	Com- bined						
				Pounds	Pounds	Per cent	Per cent	Per cent	Gallons	Per cent	Hours	° C.	Pounds	Pounds
DIFFUSE POROUS														
Aspen (<i>Populus tremuloides</i>)	-----	364	Nov. 26, 1917	59.4	52.2	4.15	3.02	1.13	-----	-----	7.00	153	100	14
Balsam poplar (<i>Populus bal- samifera</i>),	796	400	Sept. 20, 1920	78.0	53.6	5.23	3.65	1.58	-----	-----	3.50	154	100	10
-----	-----	462	Sept. 22, 1920	81.8	54.2	4.56	3.56	1.00	107.5	-----	8.00	153	100	10
-----	-----	463	Sept. 23, 1920	86.5	52.2	4.51	3.38	1.13	125.6	-----	3.50	153	100	4
Largetooth aspen (<i>Populus grand- identata</i>),	-----	570	Apr. 19, 1921	66.3	57.8	5.21	4.13	1.08	-----	-----	8.00	153	100	10
-----	-----	496	Nov. 16, 1920	106.2	57.7	5.15	4.05	1.10	109.1	-----	8.00	153	100	10
Norway poplar (<i>Populus canad- ensis eugenei</i>),	807	499	Nov. 19, 1920	103.2	51.6	5.10	3.98	1.12	113.0	-----	6.75	153	100	4
-----	-----	426	Mar. 17, 1920	71.0	60.9	5.36	4.23	1.13	95.8	44.5	8.00	153	100	10
Yellow poplar (<i>Liriodendron tulipi- fera</i>),	750	427	Mar. 18, 1920	80.7	68.7	4.57	3.50	1.07	82.7	32.6	7.00	154	100	2
-----	-----	501	May 31, 1921	70.1	51.6	4.60	4.37	1.23	117.3	-----	8.00	153	100	10
Basswood (<i>Tilia glabra</i>)	-----	587	June 2, 1921	64.6	50.6	5.00	3.77	1.23	118.5	-----	8.00	152	75	6
-----	-----	362	Nov. 22, 1917	64.7	56.6	4.27	3.17	1.10	-----	-----	6.50	153	100	10
Black willow (<i>Salix nigra</i>)	308	378	July 29, 1919	62.6	57.2	4.37	3.29	1.08	-----	-----	7.00	152	100	10
-----	-----	481	Oct. 19, 1920	76.0	64.4	5.34	4.17	1.17	87.5	40.0	8.00	154	100	10
Sandbar willow (<i>Salix longifolia</i>)	-----	492	Nov. 10, 1920	39.0	34.4	3.57	2.60	.97	119.2	-----	3.50	153	100	4
-----	-----	595	June 15, 1921	86.4	70.0	5.58	4.30	1.28	86.2	-----	8.00	152	100	6
Red maple (<i>Acer rubrum</i>)	821	597	June 17, 1921	79.8	64.1	5.55	4.36	1.19	87.0	-----	3.75	148	100	10
-----	-----	514	Jan. 10, 1921	95.0	83.1	5.27	4.24	1.03	74.2	-----	8.00	153	100	10
Sugar maple (<i>Acer saccharum</i>)	-----	556	Mar. 22, 1920	79.7	71.2	5.18	4.13	1.05	90.2	-----	4.75	148	100	4
-----	-----	485	Oct. 25, 1920	97.7	83.3	5.42	4.37	1.05	70.7	-----	8.00	153	100	10
Paper birch (<i>Betula papyrifera</i>)	794	488	Oct. 29, 1920	109.9	82.0	3.81	2.90	.91	74.8	-----	2.50	155	100	6
-----	-----	367	Nov. 28, 1917	93.7	79.6	4.84	3.74	1.10	-----	-----	8.00	152	100	10
Yellow birch (<i>Betula lutea</i>)	500	601	Sept. 22, 1921	115.4	88.0	5.44	4.48	.96	71.9	-----	4.25	147	100	30
Black gum (<i>Nyssa sylvatica</i>)	821	599	Oct. 19, 1921	86.3	72.5	5.04	4.12	.92	85.7	-----	6.75	153	100	14
-----	-----	577	Apr. 29, 1921	57.9	51.8	5.45	4.16	1.29	124.5	-----	8.00	153	100	10
Tupelo gum (<i>Nyssa aquatica</i>)	814	578	May 17, 1921	90.9	78.8	5.44	4.36	1.08	75.8	-----	4.25	153	100	4

	2	2	Feb.	5, 1907	45.0	39.8	4.31	2.84	1.47	101.0	36.4	5.70	5.00	7.50	152	84
Red gum (<i>Liquidambar styraciflua</i>)	{	{	317	Dec. 5, 1916	96.0	74.4	5.87	4.57	1.30	---	---	7.50	2.00	7.50	144	90
Cucumber magnolia (<i>Magnolia acuminata</i>)	{	{	363	Nov. 23, 1917	75.0	66.1	4.82	3.62	1.20	---	---	8.00	3.00	8.00	153	100
Sweet bay (<i>Magnolia virginiana australis</i>)	{	{	380	July 30, 1919	61.1	54.6	5.38	4.16	1.22	103.0	50.6	8.00	3.25	8.00	152	100
	{	{	385	Aug. 6, 1919	66.7	59.3	4.38	3.28	1.10	98.3	37.0	8.00	6.25	8.00	153	100
	{	{	590	June 7, 1921	100.6	86.4	5.43	4.18	1.25	69.6	---	8.00	3.75	8.00	148	100
	{	{	592	June 9, 1921	93.9	80.2	5.78	4.62	1.16	76.1	---	8.00	3.75	8.00	153	100
Sycamore (<i>Platanus occidentalis</i>)	{	{	411	Nov. 29, 1919	91.4	81.2	5.55	4.44	1.11	70.4	33.8	8.00	4.00	8.00	153	100
	{	{	563	Apr. 7, 1921	88.6	78.4	5.04	3.76	1.28	75.9	---	7.00	4.50	7.00	148	100
Butternut (<i>Juglans cinerea</i>)	{	{	543	Mar. 1, 1921	91.5	72.4	4.95	3.83	1.12	79.9	---	8.00	3.75	8.00	153	100
	{	{	545	Mar. 3, 1921	84.6	66.4	5.38	4.13	1.25	86.2	---	7.00	3.00	7.00	153	100
Ohio Buckeye (<i>Aesculus glabra</i>)	{	{	606	Oct. 4, 1921	96.0	49.8	5.65	4.43	1.22	131.0	---	6.50	3.50	6.50	145	100
	{	{	618	Nov. 16, 1921	---	---	5.01	3.75	1.26	---	---	7.00	3.00	7.00	146	100

¹ Impregnation used.

TABLE 14.—Cooking and strength data: Hardwoods—Diffuse porous—Sulphate process—Continued

Species	Cooking data—Continued					Strength data										Conditions during test	
	Ship- ment No.	Cook No.	Date	Yields based on oven-dry weight of chips charged		Bleach avail- able chlor- ine per 100 pounds oven- dry pulp	Weight per ream 24 x 36- 500	Thick- ness 0.001 in.	Mullen test per square inch	Strength factor pound per ream	Aver- age stretch	Aver- age break- ing length Meters	Aver- age double- folds	Aver- age Elmen- dorf tearing test	Rela- tive humid- ity	Tem- pera- ture	
				Crude pulp	Screen- ings												
DIFFUSE POROUS																	
Aspen (Populus tremu- loides)		364	Nov. 26, 1917	50.3	0.05	Pounds 10	Pounds 51.0	4.6	24.6	0.48	Per cent 2.07	Meters 4,262	28		Per cent 63	° F. 73	
		460	Sept. 20, 1920	45.7	.03	7	58.5	4.0	27.4	.47	1.77	4,516	26		65	88	
Balsam poplar (Populus balsamifera).	796	462	Sept. 22, 1920	47.1	.04	5	79.0	5.5	37.2	.47	1.83	4,148	30		84	86	
		463	Sept. 23, 1920	51.0	.09	6	75.5	5.0	39.4	.52	2.33	4,800	63		86	83	
Largetooth aspen (Populus grandidentata)		570	Apr. 19, 1921	46.7	.90	18	66.1	4.7	18.7	.28	1.76	2,808	1		66	75	
		496	Nov. 16, 1920	48.5	.13	11	59.5	4.4	28.3	.48	1.62	4,740	13		65	68	
Norway poplar (Populus canadensis eugenei).	807	469	Nov. 19, 1920	50.0	.19	16	75.5	5.4	31.5	.42	1.44	4,446	6		65	71	
		426	Mar. 17, 1920	47.2	.68	20	62.3	5.1	14.9	.24	1.65	3,071	14		65	72	
Yellow poplar (Liriodendron tulipifera).	750	427	Mar. 18, 1920	45.4	.60	24	55.5	5.0	15.7	.28	1.65	3,614	18		66	74	
		585	May 31, 1921	46.4		2	55.7	4.8	15.2	.27	1.61	2,729	6		66	90	
Blackwood (Tilia glabra)	501	587	June 2, 1921	48.4	.71	19	54.5	5.5	27.1	.46	1.81	3,710	18		66	94	
		362	Nov. 22, 1917	57.3	.05	18	59.5	5.5	27.1	.46	1.81	3,710	18		66	94	
Black willow (Salix nigra)	368	378	July 29, 1919	50.8		15	57.1	4.1	20.0	.35	1.66	3,933	15		61	69	
		484	Oct. 19, 1920	45.3	.20	7	76.5	5.5	25.7	.34	1.42	3,953	5		68	71	
Sandbar willow (Salix longi- folia).		492	Nov. 10, 1920	47.8	.36	10	85.0	6.5	40.4	.48	1.57	4,253	6		64	72	
Red maple (Acer rubrum).	821	595	June 15, 1921	48.7	.22	9	56.0	5.0	16.5	.30	1.77	2,952	3		66	93	
		514	Jan. 10, 1921	44.1	.12	8	92.5	7.2	38.0	.30	1.75	2,948	3		66	93	
Sugar maple (Acer saccha- rum).		556	Mar. 22, 1921	47.0	.62	18	66.0	5.1	32.3	.41	1.34	4,585	21		65	71	
Paper birch (Betula papy- rifera).	794	485	Oct. 25, 1920	40.6	.30	10	89.7	6.9	30.6	.34	1.35	3,208	13		65	74	
		488	Oct. 29, 1920	49.2	.20	17	56.6	4.0	17.5	.31	1.27	3,354	8		64	76	
Yellow birch (Betula lutea)	500	367	Nov. 28, 1917	47.2	.03	20	53.8	5.0	18.7	.35	1.82	3,263	14		68	73	
		601	Sept. 22, 1921	45.8	.85	16	63.2	4.9	20.2	.32	1.71	3,466	7		65	70	
Black gum (Nyssa sylvat- ica).	821	599	Oct. 19, 1921	45.6	.03	15	60.4	5.1	15.6	.26	1.53	2,735	26		65	70	

	814	{	577	Apr. 29, 1921	46.5	.78	22	Yes--	108.5	9.0	22.2	.20	1.38	2,242	8	203	65	85
Tupelo gum (<i>Nyssa aquatica</i>).	2	{	578	May 17, 1921	43.2	.17	12	Yes--	79.3	6.3	21.8	.28	2.01	3,034	6	138	65	88
Red gum (<i>Liquidambar styraciflua</i>).	401	{	317	Feb. 5, 1907	44.6	.42	17	Yes--	70.0	6.9	15.7	.22	1.30	2,840	2	---	62	---
Cucumber magnolia (<i>Magnolia acuminata</i>).	511	{	363	Dec. 5, 1916	46.7	.06	37	Yes--	52.8	5.3	16.8	.32	1.90	2,900	4	---	64	72
Sweet bay (<i>Magnolia virginiana australis</i>).	814	{	380	Nov. 23, 1917	45.8	.03	28	Yes--	68.0	6.2	19.8	.29	1.26	3,048	5	---	63	66
Sycamore (<i>Platanus occidentalis</i>).	---	{	385	July 30, 1919	48.2	.13	25	Yes--	68.0	6.1	18.7	.27	1.64	3,360	6	---	65	71
Butternut (<i>Juglans cinerea</i>).	791	{	590	Aug. 6, 1919	44.5	.44	15	Yes--	53.0	4.1	14.6	.34	1.92	2,294	4	---	65	86
Ohio Buckeye (<i>Aesculus glabra</i>).	863	{	592	June 7, 1921	43.1	.37	12	Yes--	54.0	3.9	18.5	.36	2.58	3,170	85	---	66	93
			411	June 9, 1921	46.7	---	11	Yes--	65.1	5.8	10.2	.16	1.27	2,178	2	---	65	69
			563	Nov. 29, 1919	47.2	---	18	Yes--	68.0	5.7	14.4	.21	1.26	3,159	16	---	66	76
			543	Apr. 7, 1921	46.0	.47	18	Yes--	74.6	5.3	20.1	.27	2.47	2,777	5	---	65	97
			545	Mar. 1, 1921	46.7	.05	18	Yes--	71.0	5.6	23.8	.34	2.06	3,239	6	---	66	72
			606	Mar. 3, 1921	46.7	.13	18	Yes--	67.0	5.1	20.3	.30	1.82	3,646	5	---	64	78
			618	Oct. 4, 1921	48.9	.72	24	Yes--	64.1	5.6	31.4	.49	1.58	4,868	15	105	65	69
				Nov. 16, 1921	(*)	---	24	Yes--	---	---	---	---	---	---	---	---	---	---

² Pulp very shivvy.³ Soft, uniformly cooked pulp, light colored and free from shive or specks.⁴ Yield data lost. Probably 45 to 50 per cent.

	821	767	May 25, 1912	71.6	54.5							78.5	19.6	20.0	5.0	30.6	95.1
Sugar maple (<i>Acer saccharum</i>)	768	768	May 26, 1921	106.2	82.9							100.0		25.0		30.0	91.1
Paper birch (<i>Betula papyrifera</i>)	337	799	Oct. 7, 1921	104.2	90.6							75.0	25.0	18.8	6.3	30.0	95.0
	794	800	Oct. 10, 1921	103.9	90.5							100.0		25.0		30.0	87.8
	794	283	Oct. 27, 1920	104.8	90.2							124.0		26.1		25.4	85.5
	205	284	Nov. 1, 1920	106.3	91.4							97.3	19.7	24.4	5.0	30.0	82.2
Yellow birch (<i>Betula lutea</i>)	500	205	Nov. 12, 1917	93.1	80.4							90.0	31.1	12.4	4.3	16.4	93.0
	154	154	July 2, 1917	102.0	82.2							80.2		20.3		30.3	93.0
	226	226	Jan. 8, 1918	74.6	63.5							91.3		27.9		36.6	75.0
Beech (<i>Fagus grandifolia</i>)	7	7	July 9, 1909	25.0	21.8							91.0		27.9		37.2	
	7	7	Aug. 19, 1909	25.0	22.1							90.0		28.2		37.3	
Black gum (<i>Nyssa sylvatica</i>)	818	20	Dec. 4, 1920	134.8	79.2							103.0		28.4		33.0	86.2
	818	19	Dec. 3, 1920	135.9	76.8							89.0	11.6	23.7	3.1	32.0	92.4
Tupelo gum (<i>Nyssa aquatica</i>)	814	745	Apr. 14, 1921	87.9	75.6							78.5	20.0	19.6	5.0	30.0	89.5
Red gum (<i>Liquidambar styraciflua</i>)	818	746	Apr. 18, 1921	85.8	73.6							100.0		25.2		30.3	92.3
	818	36	Jan. 25, 1921	133.4	73.8							103.3		28.4		33.0	84.5
	801	36	Feb. 4, 1921	142.5	70.6							87.7	11.3	24.1	3.1	33.0	87.7
	742	742	Apr. 17, 1921	122.4	90.8							79.6	19.9	20.3	5.1	30.6	89.8
Cucumber magnolia (<i>Magnolia acuminata</i>)	511	225	Jan. 17, 1918	71.0	57.4							74.4		20.0		30.0	87.0
Sweet bay (<i>Magnolia virginiana australis</i>)	814	773	June 3, 1921	102.1	64.5							80.0	20.0	20.0	5.0	30.0	94.8
	814	774	June 6, 1921	102.1	87.2							80.0	20.0	20.0	5.0	30.0	94.8
	18	775	June 16, 1921	105.6	92.8							100.0		23.0		30.0	91.3
Sycamore (<i>Platanus occidentalis</i>)	791	254	Aug. 16, 1909	25.0	22.0							80.0		23.0		43.6	90.4
	791	737	Jan. 30, 1920	91.6	81.4							98.0		22.9		27.8	93.0
Butternut (<i>Juglans cinerea</i>)	791	737	Apr. 4, 1921	91.5	80.5							80.0	20.0	20.0	5.0	30.0	94.5
Ohio Buckeye (<i>Aesculus glabra</i>)	863	735	Mar. 28, 1921	81.5	64.9							77.8		13.3		30.0	80.0
	757	736	Mar. 29, 1921	78.4	63.5							72.4	19.7	13.8	4.9	30.0	91.9
	798	757	Oct. 3, 1921	110.3	58.5							73.0	25.0	13.8	6.3	30.0	89.4
	751	798	Oct. 6, 1921	108.8	57.0							100.0		23.0		36.0	84.7
	751	289	Oct. 13, 1920	40.9	35.6							68.6	17.1	20.0	5.0	35.0	

1 Shavings used.

TABLE 16.—Cooking and strength data: Hardwoods—ring-porous, miscellaneous (palmetto)—Sulphite process

Species	Ship- ment No.	Cook No.	Date	Quantity of wood used		Cooking liquor				Cooking data					Cooking period				
				Moist weight	Oven- dry weight	Composition			Per 100 pounds chips		Time to maxi- mum tem- per- ature	Time to maxi- mum pres- sure	Dura- tion of cook	Maxi- mum tem- per- ature	Maxi- mum pres- sure per square inch	Gas pres- sure at blow per square inch			
						Total	Free	Com- bined	Volume	SO ₂									
Pounds	Pounds	Per cent	Per cent	Per cent	Gallons	Per cent	Hours	Hours	° C.	Hours	Pounds	Pounds							
RING POROUS																			
Common catalpa (<i>Catalpa bignonioides</i>).	802	490	Nov. 8, 1920	90.9	69.2	5.40	4.40	1.00	84.6	Per cent	7.75	2.75	7.75	152	100	13			
		495	Nov. 15, 1920	87.6	65.0	3.84	2.70	1.14	83.4	Per cent	8.00	4.50	8.00	153	100	14			
Chestnut (<i>Castanea dentata</i>).		388	Aug. 12, 1919	76.6	69.7	4.35	3.27	1.08	83.5	Per cent	7.75	5.00	7.75	152	100	12			
		568	Apr. 15, 1921	61.9	45.5	5.37	4.21	1.16	56.2	Per cent	7.00	3.00	7.00	148	100	4			
Hackberry (<i>Celtis occidentalis</i>).		582	May 23, 1921	80.5	76.0	5.56	4.42	1.14	78.8	Per cent	8.00	2.00	8.00	148	100	4			
		586	June 1, 1921	98.3	83.1	5.32	4.12	1.20	73.0	Per cent	7.00	4.25	7.00	148	100	4			
Sassafras (<i>Sassafras varifolium</i>).		607	Oct. 6, 1921	99.2	67.2	5.32	4.32	1.00	91.3	Per cent	6.00	3.00	6.00	144	100	10			
	862	611	Oct. 21, 1921	100.4	66.0	4.97	3.94	1.03	96.0	Per cent	7.25	4.00	7.25	148	100	29			
Rock elm (<i>Ulmus racemosa</i>).		414	Jan. 12, 1920	112.0	85.5	5.37	4.27	1.10	66.7	Per cent	8.00	2.75	8.00	153	100	24			
	564	416	Feb. 10, 1920	124.2	96.7	6.24	4.76	1.48	58.2	Per cent	8.00	3.00	8.00	153	100	10			
		579	May 18, 1921	151.6	107.8	5.30	4.24	1.06	55.8	Per cent	7.00	3.00	7.00	149	100	16			
Slippery elm (<i>Ulmus fulva</i>).		381	May 20, 1921	125.4	85.3	5.15	4.00	1.15	72.6	Per cent	7.00	2.75	7.00	148	100	5			
		385	Nov. 28, 1917	80.5	65.8	5.19	3.91	1.28	67.4	Per cent	8.00	3.25	8.00	153	100	5			
White ash (<i>Fraxinus americana</i>).		531	Mar. 15, 1921	105.2	88.0	5.29	4.20	1.09	67.4	Per cent	7.00	3.50	7.00	148	100	4			
		396	Dec. 5, 1917	145.7	92.7	4.35	3.30	1.05	57.7	Per cent	8.00	2.25	7.00	153	100	10			
Red oak (<i>Quercus borealis maxima</i>).	531	526	Jan. 28, 1921	80.6	70.3	5.35	4.23	1.12	78.3	Per cent	7.25	3.50	8.00	153	100	10			
		387	Aug. 11, 1919	84.4	74.3	4.34	3.24	1.10	72.3	Per cent	7.25	4.25	7.25	154	100	4			
White oak (<i>Quercus alba</i>).	531	569	Apr. 18, 1921	90.1	79.6	5.20	4.10	1.10	72.3	Per cent	7.00	3.25	7.00	148	100	3			
		560	Mar. 29, 1921	116.4	91.4	5.08	4.00	1.08	67.2	Per cent	8.00	2.75	8.00	153	100	10			
Mockernut hickory (<i>Hicoria alba</i>).	791	564	Apr. 8, 1921	108.0	87.0	5.03	3.98	1.05	71.2	Per cent	7.00	2.50	7.00	152	100	6			
		567	Apr. 14, 1921	103.1	85.4	5.43	4.28	1.15	72.3	Per cent	7.75	2.00	7.75	152	100	12			
Black locust (<i>Robinia pseudoacacia</i>).		571	Apr. 20, 1921	95.3	80.9	5.05	3.85	1.20	78.3	Per cent	7.00	2.00	7.00	153	100	4			
MISCELLANEOUS																			
Cabbage palmetto (<i>Sabal palmetto</i>).		573	Apr. 22, 1921	155.4	84.0	5.40	4.30	1.10	74.0	Per cent	6.75	3.75	6.75	147	100	9			

Cooking data—Continued				Strength data										Conditions during test			
Species	Ship- ment No.	Cook No.	Date	Yields based on oven-dry weight of chips charged		Bleach required per cent avail- able chlor- (lime) per 100 pounds oven- dry pulp	Calen- dered	Weight per ream 24x36— 500	Thick- ness	Mullen test per square inch	Strength factor per pound ream	Aver- age stretch	Aver- age break- ing length	Aver- age double- folds	Aver- age Elmen- dorf tearing test	Relative humid- ity	Tem- pera- ture
				Crude pulp	Screen- ings												
				Per cent	Per cent	Pounds		Pounds(0.001 in.	Pounds	Points	Per cent	Meters		Grams	Per cent	° F.	
RING POROUS																	
Common catalpa (Catalpa bignonioides), Chestnut (Castanea den- tata), Hackberry (Celtis occiden- talis), Sassafras (Sassafras varifo- lium), Rock elm (Ulmus racemosa), Slippery elm (Ulmus fulva), White ash (Fraxinus amer- icana), Red oak (Quercus borealis maxima), White oak (Quercus alba), Mockernut hickory (Hico- ria alba), Black locust (Robinia pseudoacacia).	{ 802 -----																

¹ Unbleached pulp pink. ² Unbleached pulp specky and pink. ³ Unbleached pulp clear but green. ⁴ Unbleached pulp very dark colored and raw. ⁵ Unbleached pulp specky. ⁶ Unbleached pulp dark colored and raw. ⁷ Unbleached pulp of fair color but specky. ⁸ Unbleached pulp dark colored, raw, and brash.

Cooking data—Continued

Species	Shipment No.	Cook No.	Date	Steam			Yields based on oven-dry weight of chips charged			Calendered	Weight per ream 24 x 36—500	Thickness	Mullen test per square inch	Strength factor per pound	Average stretch	Average breaking length	Average double folds	Average Elmendorf tearing test	Condi- tions dur- ing tests	
				Maximum pres- sure per square inch	Pressure increased	Min- utes	Min- utes	Per cent	Crude pulp										Screenings	Oil per ton bone- dry chips
RING POROUS	Common catalpa (Catalpa bignonioides).	287	Nov. 4, 1920	100	75	300	35.6	---	---	---	---	---	---	---	---	---	---	---	---	---
		298	Nov. 5, 1920	105	60	360	42.9	---	---	---	---	---	---	---	---	---	---	---	---	---
	Chestnut (Castanea dentata)	65	July 28, 1916	120	30	180	37.8	0.02	---	---	---	---	---	---	---	---	---	---	---	---
		144	July 31, 1916	120	15	165	33.8	.04	---	---	---	---	---	---	---	---	---	---	---	---
	Hackberry (Celtis occidentalis).	762	May 13, 1917	100	15	240	43.0	.00	---	---	---	---	---	---	---	---	---	---	---	---
		763	May 17, 1921	102	70	360	32.4	---	---	---	---	---	---	---	---	---	---	---	---	---
	Sassafras (Sassafras variifolium).	801	May 18, 1921	100	75	300	41.0	---	---	---	---	---	---	---	---	---	---	---	---	---
		802	Oct. 11, 1921	105	60	360	40.4	---	---	---	---	---	---	---	---	---	---	---	---	---
	Rock elm (Ulmus racemosa)	564	Oct. 12, 1921	100	60	300	29.0	---	---	---	---	---	---	---	---	---	---	---	---	---
		281	Jan. 26, 1920	82	105	480	45.3	---	---	---	---	---	---	---	---	---	---	---	---	---
Slippery elm (Ulmus fulva)	7	Sept. 30, 1920	105	90	285	45.5	---	---	---	---	---	---	---	---	---	---	---	---	---	
	764	May 19, 1921	50	60	900	41.6	---	---	---	---	---	---	---	---	---	---	---	---	---	
American elm (Ulmus americana).	786	May 23, 1921	100	60	360	33.2	---	---	---	---	---	---	---	---	---	---	---	---	---	
	787	June 23, 1921	100	70	300	39.3	---	---	---	---	---	---	---	---	---	---	---	---	---	
White ash (Fraxinus americana).	505	June 24, 1921	102	60	360	40.3	---	---	---	---	---	---	---	---	---	---	---	---	---	
	785	June 24, 1921	102	60	360	40.3	---	---	---	---	---	---	---	---	---	---	---	---	---	
Red oak (Quercus borealis maxima).	788	Feb. 9, 1920	92	75	345	41.2	---	---	---	---	---	---	---	---	---	---	---	---	---	
	794	June 27, 1921	100	75	300	38.9	.03	---	---	---	---	---	---	---	---	---	---	---	---	
White oak (Quercus alba)	531	Sept. 29, 1921	100	60	300	38.4	---	---	---	---	---	---	---	---	---	---	---	---	---	
	227	Nov. 23, 1917	80	25	215	58.7	.03	---	---	---	---	---	---	---	---	---	---	---	---	
Mockernut hickory (Hicoria alba).	795	Jan. 9, 1918	95	25	310	34.8	---	---	---	---	---	---	---	---	---	---	---	---	---	
	739	Sept. 30, 1921	100	70	300	43.6	---	---	---	---	---	---	---	---	---	---	---	---	---	
Black locust (Robinia pseudo-acacia).	740	Apr. 6, 1921	102	45	300	29.8	---	---	---	---	---	---	---	---	---	---	---	---	---	
	822	Apr. 7, 1921	100	60	360	36.4	---	---	---	---	---	---	---	---	---	---	---	---	---	
Ailanthus (Ailanthus altissima).	2042	Apr. 26, 1921	100	75	360	41.2	---	---	---	---	---	---	---	---	---	---	---	---	---	
	2047	Apr. 27, 1921	87	70	330	44.2	---	---	---	---	---	---	---	---	---	---	---	---	---	
	998	Mar. 3, 1924	100	120	240	48.0	---	---	---	---	---	---	---	---	---	---	---	---	---	
			Apr. 1, 1924	100	90	270	50.4	---	---	---	---	---	---	---	---	---	---	---	---	

1 Extracted chips retained on screen.

2 Extracted chips unscreened.

3 Unextracted chips.

TABLE 18.—Cooking and strength data: Miscellaneous species, Chilean woods—Soda or sulphate process

Cooking data																			
Species	Shipment No.	Cook No.	Date	Quantity of wood used		Impregnating liquor						Penetration		Cooking liquor			Black liquor ratio combined to total alkali		
				Moist weight	Oven-dry weight	Before penetration			After penetration			Duration	Pressure per square inch	Temperature	Concentration			Per 100 pounds bone-dry chips	
						Volume	NaOH	Grams per liter	NaOH	Grams per liter	NaOH				Grams per liter	NaOH			Grams per liter
MISCELLANEOUS	213	{ 3 5 4 751 754 789 5 7 711	Oct. 31, 1912	Lbs.	Lbs.	Gal- lons	Grams per liter	NaOH	Grams per liter	Gal- lons	Grams per liter	NaOH	Grams per liter	NaOH	Grams per liter	NaOH	Grams per liter	Per cent	
Soapweed (Yucca elata)			11.0	0.8	---	---	---	---	---	---	---	---	---	---	---	---	---	---	80.2
---			3.1	0.8	---	---	---	---	---	---	---	---	---	---	---	---	---	---	96.6
---			3.1	1.0	---	---	---	---	---	---	---	---	---	---	---	---	---	---	34.2
---			125.6	66.1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	36.2
Cabbage palmetto (Sabal palmetto).			130.8	74.4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	34.2
---			74.4	74.4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	36.2
Cane (Arundinaria macrosperma).	711	{ 5 7	Apr. 25, 1921	25.0	4.0	---	---	---	---	---	---	---	---	---	---	---	---	95.9	
---			74.4	74.4	---	---	---	---	---	---	---	---	---	---	---	---	---	91.7	
---			25.0	21.3	---	---	---	---	---	---	---	---	---	---	---	---	---	---	91.9
---	---	---	Feb. 16, 1909	52.9	4.0	---	---	---	---	---	---	---	---	---	---	---	---	85.2	
---	---	---	Feb. 24, 1909	52.9	4.0	---	---	---	---	---	---	---	---	---	---	---	---	85.2	
CHILEAN WOODS	---	{ 13 14 15 16 11 18	Mar. 23, 1915	76.0	38.6	---	---	---	---	---	---	---	---	---	---	---	---	---	
Olivillo			76.0	40.0	---	---	---	---	---	---	---	---	---	---	---	---	---	---	
Laurel (Laurelia aromatica)			72.0	40.0	---	---	---	---	---	---	---	---	---	---	---	---	---	---	
Coigue (Nothofagus dombeyi)			66.3	40.0	---	---	---	---	---	---	---	---	---	---	---	---	---	---	
Lingue (Persea lingue)			38.4	20.0	---	---	---	---	---	---	---	---	---	---	---	---	---	---	
Roble-pellin (Nothofagus obliqua)			2.3	2.0	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Quillai (Quillaja saponaria)	---	---	Mar. 30, 1915	76.0	38.6	---	---	---	---	---	---	---	---	---	---	---	---		

Species	Cooking data—Continued										Strength data																
	Shipment No.	Cook No.	Date	Steam			Yields based on oven-dry weight of chips charged			Bleach required (35 per cent available chlorine) per 100 pounds oven-dry pulp	Strength data					Average double folds	Average Elmendorf tearing	Conditions during tests									
				Maximum pressure	Inch	Pressure increased	Minutes	Duration at maximum pressure	Crude pulp		Screenings	Oil per ton bone-dry chips	Calendered	Weight per ream 24 x 36-500	Thickness				Mullen test per square inch	Strength factor per pound	Average stretch	Average breaking length					
				Lbs.	Minutes	Minutes	Per cent	Gal- lons	Lbs.																		
MISCELLANEOUS	213	{ 3 3 4 751 754 789	Oct. 31, 1912	50	60	300	40.2																				
			Nov. 6, 1912	50	45	315	38.2																				
			Nov. 4, 1912	80	45	255	24.9																				
			Apr. 25, 1921	102	240	360	35.4																				
			Apr. 28, 1921	102	180	240	32.0																				
Cane (Arundinaria macro-sperma).	711	{ 7 5 5 711 711	July 19, 1921	60	120	360	42.8																				
			Feb. 16, 1909	100	30	420	42.1																				
			Feb. 24, 1909	100	15	540	33.2																				
CHILEAN WOODS		{ 13 14 15 16 11 18	Mar. 23, 1915	100	90	330	38.8																				
			Mar. 24, 1915	100	90	330	40.3																				
			Mar. 25, 1915	100	60	360	42.0																				
			Mar. 26, 1915	100	60	360	41.0																				
			Mar. 22, 1915	100	60	420	31.4																				
			Mar. 30, 1915	100	60	30	45.1																				

¹ Only bark used.

² Leaves.

³ Stalks.

⁴ Bleached and run with 25 per cent bleached spruce sulphite into excellent book paper.

⁵ Excellent pulp.

⁶ Bleaching action slower than usual.

⁷ Unbleached pulp light colored and of good average fiber length.

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April 25, 1927

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